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AMERICAN PHILOSOPHICAL SOCIETY.

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A Discourse, illustrative of the life and character of HORACE BINNEY, *delivered before the Bar of Philadelphia, the Law Association, and the American Philosophical Society, in the Musical Fund Hall, on the evening of Jan.* 5, 1876.

BY JUDGE WILLIAM STRONG.

Forty years ago, in this Hall, on an occasion much like the present, Mr. Binney commenced his eulogy of Chief Justice Marshall with the following remark, "The Providence of God is shown most beneficently to the world, in raising up, from time to time, and in crowning with length of days, men of pre-eminent goodness and wisdom." The thought thus expressed is worthy of recall to-day. At intervals, all along the line of human history, and especially in enlightened communities, men have appeared, who, by their native endowments, their thorough culture, their ceaseless energy, and their moral worth, have raised themselves to a plane above that of their fellows; men who have been in advance of all their cotemporaries, and to whom the rank of leaders has been universally conceded. Such

leaders have arisen in every department of social life, in the learned professions, among the devotees to fine arts, in the regions of invention, in the explorations of natural science, in mechanical pursuits, in those of commerce, and even in the department of agriculture. Occasionally some noted one has lifted his standard of attainment higher than that of any of his predecessors, and has gone forward beyond their utmost reach. Such men are among the best gifts to the world, of a beneficent God. It is through their agency society makes progress. They lead the onward way. Their lives lend attractive force to that which is truly valuable. They present models for imitation, and their achievements stimulate to a generous rivalry. Their standard, "full high advanced," is ever visible, and it calls, with a noiseless but persuasive voice, to those who are behind to move onward. No one can overestimate the value of such a life to young men in the legal profession, if it be kept ever in view. If they have not mistaken their calling, it must win their admiration, and stir the noblest impulses of their hearts. It is a perpetual reproof of contentment with any attainments less than the highest possible, a rebuke of character and conduct unbecoming the best aims, and it gives courage for the grandest efforts.

Happily the lessons of such a life are beyond the reach of death. They are the rightful property of more than one generation. They ought never to fade into oblivion. To preserve them with gratitude for

the past and with hope for the future, is a duty which the living owe to themselves and to those who shall come after them. And this duty is best performed as a skillful painter preserves in memory the subject of his portrayal. A portrait is not a life, it is true, but it recalls a life. So a delineation of character and achievement, if it be accurate, prolongs the influences the character is fitted to exert. It is therefore in obedience to your desire to perpetuate, so far as may be, the instruction and example of a life more than commonly eminent and useful, that I am to speak to you of Horace Binney.

He was born in Philadelphia on the 4th day of January, A. D., 1780, in a house belonging to Thomas Williams, in what was then known as the Northern Liberties, and in the neighborhood of Front and Coates streets. He was of Scotch and English descent. The earliest paternal ancestor of whom he had knowledge was John Binney, who, in 1680, resided with his wife Mercy, in the town of Hull, Boston Bay, in England, and from whom he was the fifth by descent in right line. The family came to this country about that time and settled in Hull, Massachusetts. The grandfather of Horace was Barnabas Binney, a shipmaster and merchant of Boston, and his father (born in 1751,) named also Barnabas Binney, was a surgeon in the revolutionary army, attached to the Massachusetts line, whence he was transferred to the Pennsylvania line. After his transfer he settled permanently in

Philadelphia, and, in 1777, he married Mary, the eldest daughter of Henry Woodrow, a man of Scotch ancestry, a whig in politics, of great purity of character and uprightness of life. Dr. Barnabas Binney was a man of liberal education, and a graduate in 1774 of Brown University, where he attained the highest distinction in his class. Thence he came to this city, and attended medical lectures at the University, in due time receiving from it a degree. He was an accomplished "belles-lettres" scholar, and acutely sensitive to the beauties of English literature. He wrote with ease and elegance, and he cherished both the taste and the talent for poetical composition. Withal his intellectual powers were fine, and he had a strength of principle, a decision and energy of action, and a sensibility and tenderness of feeling that commanded the respect of all who knew him, and greatly endeared him to the circle of his domestic friends.

Dr. Binney's wife, the mother of Horace, was also a superior person. In many points her intellectual traits and those of her husband were much alike. She had besides a keen perception and taste for wit and humor, and a remarkable faculty for catching and imitating personal peculiarities of manner, voice, and almost of look. In the character of her mind there was a large element of the dramatic. Her manner was impressive, and she had that rare union of dignity and ease which woman alone possesses, without the appearance of effort, and which she only can teach.

At the age of six years, Horace was sent to his first school, which, for a short time, was the Friends' Alms House School, in Walnut street between Third and Fourth. Very soon afterwards, he entered the Grammar school of the University of Pennsylvania, where he remained until his father's death, which occurred in 1787. Thus early, when only seven years of age, he was left an orphan, in charge of a widowed mother. In 1788 he was placed in a school at Bordentown, New Jersey, where he continued three years, and acquired the reputation of being the best scholar in the school; beginning thus early to give promise of what he afterwards became. His attainments in knowledge of the Greek language especially, must have been remarkable for a youth of only ten or eleven years. And not only was his scholarship of an high order, but his conduct was such as to commend him to the confidence of his teachers, for he was promoted to be "guider" of boys older than himself.

Leaving Bordentown in 1791, he returned to his mother's residence, in Philadelphia, then on Market between Fifth and Sixth streets, immediately opposite the residence of General Washington, and adjoining that of Alexander Hamilton. There he frequently saw the first President of the United States, as also Mrs. Washington, who was his mother's friend, of both of whom he had perfect recollection throughout his life. There he was also a witness of the ceremonies of the day; imposing ceremonies, which were remnants of

colonial usages derived from the mother country, but which long since went into desuetude. What effect such associations and opportunities had upon his youthful mind, never wanting in a pure and generous ambition, may readily be conjectured.

In 1791 his mother entered in a second marriage with Dr. Marshall Spring, of Watertown, Massachusetts, (now a suburb of Boston,) and in 1792 he went to reside with his stepfather, for whom he ever after felt warm affection and profound respect. Soon thereafter he was sent to a boarding-school near Medford, six miles from Boston. Even then, though only twelve years old, he was prepared for admission to college, but he was considered too young to enter, and he was sent to school rather to grow older, than to increase his intellectual preparation for college life. He did not remain long at Medford, because of a conviction he had that his master was incompetent to instruct him in the Greek language. An interesting incident is related of his short school life there, illustrative of his confidence in the accuracy of his knowledge, and of his resolute adherence to that which he believed correct, even to the extent of what may be considered rudeness. On the day after his arrival at school, he was called up to recite to his new master a Greek lesson in the New Testament. He began with confidence, but he had not proceeded far when he was stopped, and told he was wrong, and what the master deemed the proper translation was given. Instead of

accepting the correction silently, he insisted that he was right and that the master was wrong. This brought immediately the rebuke, "Is this your Philadelphia politeness?" to which he replied, "It is my Philadelphia Greek, sir."

After leaving the school at Medford, he was placed in the care of a clergyman at West Cambridge, in whose family he remained until July, 1793, when he entered the Freshmen class at Harvard University, the president of which, at that time, was the Rev. Joseph Willard, D. D. and LL. D. In the autumn after his admission he unfortunately lost his mother by her death, and thus became doubly an orphan. How he acquitted himself in college is shown by the fact that on his graduation in 1797, he divided the first honor of his class with a single classmate.

It was at Bordentown and at Harvard that Mr. Binney laid the foundation on which he subsequently built his character and his fame. Protected by Divine Providence, as he was wont to acknowledge, against the perils that even then beset the paths of young men in a college course; having an ardent desire for distinction in his class, a desire which forbade any deviation from moral rectitude, and sternly resisted every temptation to indolence, or vicious indulgence; he secured for himself all the advantages of mental and moral culture, which the most advanced collegiate education in this country could then give. Through his entire college life his intercourse with the officers of

the institution was one of one uninterrupted respect on his part, and of affectionate confidence on theirs. Knowledge, of course, he acquired, but that was the least of his acquisitions. He acquired the art and the habit of study, with an unfading love for it, and this acquisition was permanent. It continued to be his delight and a great element of his power until the close of his life. Never for a moment did he make the mistake, into which so many fall, of considering the *primary* object of a liberal education to be securing a knowledge of facts, or of arts, or of sciences which might be useful in after life. This knowledge he knew would decay. He sought and he obtained the "art of all arts the best,"—that of setting the mind intently upon a subject of thought, and holding it there until the subject is thoroughly understood.

This power or art of study which he acquired during his college life, he ever regarded as his most important gain, and many years afterward he spoke of it as such. Much of what he acquired he said he had lost. His knowledge of the Latin and Greek classics, as well as of the higher mathematics, had fallen away from disuse, though he had preserved enough to assist his children in their education, "but," he added, "the ununfading art which I acquired at college was that of study, and if the acquisitions of knowledge I then made by it are faded, or fallen from the surface, * * certainly the art or faculty of study has never left me." His appetite for study while he was in college was so

great, that on one occasion, instead of going to his stepfather's, where he was always happy, he remained in his chambers in one of the college buildings during an entire autumnal vacation, and studied every day of it fourteen hours. Habits and tastes like these were his constant shield, as well as his instruments of power; and long after his graduation he was able to say, "I look back to my college life with great satisfaction. I was a fair student of everything I was required to learn, and it does not now occur to me that I ever missed a recitation, or the chapel service at six in the morning, winter or summer. * * I have no recollection that during those four years I ever did a thing to make my friends blush, and their praises when I left college gave me courage to begin my first steps in the world."

During the year immediately preceding his graduation he began to look forward to his life work. His father and his step-father having been physicians, it was to be expected that his attention would be turned to the profession to which they had belonged. Accordingly he felt a strong desire to study medicine and surgery, and he attended a course of lectures on anatomy delivered by Dr. Warren, the father of one of his favorite classmates. He also read some medical books. But his step-father earnestly dissuaded him from attempting the profession, and induced him to give up all thought of it.

After his graduation in July, 1797, he remained in

the family of an aunt in Providence, Rhode Island, about three months. During the summer and autumn of that year, the yellow fever prevailed in Philadelphia. In November he came to Philadelphia to make it his permanent home, still undecided what employment he would select, but fitted in an unusual degree to enter upon any line of life, and to make for himself a place and a name. No thought of rest or of self-indulgence after his four years of intense application, diverted him from an earnest purpose to do what he could. He had been turned away from the profession for which he had a decided preference, and to which all his reading that was not scholastic had been directed. He felt no special attraction to any other, and the uncertainty of success in the legal profession, of which he had heard much, made him hesitate to select that. Without much reflection, therefore, he turned his attention to mercantile life, and requested Dr. David Jackson, his guardian, to apply to Cunningham and Nesbit, a firm of large shipping merchants in this city, to receive him into their counting house as an apprentice. Fortunately for himself, fortunately for the bar, and fortunately for the country, the counting-room was full, and the merchants had no place for him. It was then he made choice of the legal profession, and at his instance Dr. Jackson requested Mr. Jared Ingersoll to receive him into his office as a student of law. Mr. Ingersoll consented, and thus the work of life was determined. So narrowly did he escape a calling, to which he was

apparently not best adapted, and so Providentially was he led into the profession which he subsequently so much adorned. He had no friends in Philadelphia to advise him, none, at most, sufficiently acquainted with his peculiar qualifications to advise him judiciously, though he had been told by his step-father that if he selected any of the learned professions, it ought to be the law.

Among his fellow students in Mr. Ingersoll's office were John B. Wallace, who afterwards married his sister, and John Sergeant, both young men of remarkable mental force, and of indomitable ambition, and both of them were, from the commencement of his apprenticeship, his life long friends. Somewhat later he contracted an intimate friendship with Mr. Charles Chauncey which continued unbroken until the latter's death.

How faithfully he improved the opportunities which Mr. Ingersoll's office afforded him may be inferred from what he had done in college, and may be known from what he was after his call to the bar. He had learned to study, and in study, not in mere reading, he found his chief delight. Of course to him the new science to which his attention was directed, presented attractions above everything else. His steadfast effort was to learn his profession accurately. With this he suffered nothing to interfere, and he firmly resisted all the social temptations which assail young men in large cities. He had resources for recreation within himself.

He was extremely fond of music, playing well upon the flute, and singing with great sweetness of voice. Indeed, to the last days of his life music was to him a great joy, and in the education of his children he sought attentively to give them musical accomplishments. The two years and more which he spent in Mr. Ingersoll's office were passed with great advantage to himself, and he never forgot the debt of gratitude he owed to his preceptor. In after years he paid it to that preceptor's memory in a manner that delighted the bar, and set up an enduring monument of his own respect and affection.

Having completed his apprenticeship, Mr. Binney was admitted to the bar of the court of Common Pleas on the 31st day of March, 1800, though he was then but little over twenty years of age, and at the March Term of 1802 he was admitted to the bar of the Supreme Court of the State. At the time of his admission the Supreme court consisted of Shippen, Chief Justice, and Yeates, Smith and Breckenridge, associate justices. Before these men he made his first appearance in the highest court of the State, and from them he received a kindly treatment that he never failed gratefully to remember.

In the year 1800, and through the early part of this century the eminent men who led the legal profession in the city were William Lewis, Edward Tilghman, Jared Ingersoll, William Rawle, William Tilghman, and Alexander James Dallas. To these may be added Mr.

Duponceau, distinguished especially by his knowledge of admiralty law. They were men of varied accomplishments, but they were all men of power, conspicuous in the city and throughout the State, and to them was entrusted nearly the whole of the important legal business of the community. To a young man just entering the profession, the prospect of success in obtaining employment may have seemed gloomy. The business community, who most need the assistance of lawyers, were supplied, and well supplied. There seemed to be no room for other lawyers, and those who occupied the field were too strong in themselves, and too strongly entrenched in the confidence of the public, to be displaced. In truth, however, the circumstances that might have been thought to interpose almost insurmountable obstacles to professional success were adjuvants to it. The well-prepared and ambitious young men, who, on their admission, found at the bar a body of practitioners so eminent as were those I have named, monopolizing the honors and the emoluments of the profession, were taught at once to lift their own standard high. They learned that no moderate attainments, no half-hearted efforts, no imperfect preparation would meet the necessities of their case. They grew indeed for a time in the shade, but it was a healthy shade. The exhibitions of mental power, of legal learning, and of professional skill which they constantly witnessed were instructive to them, the subjects of their thought and conversation, and incentives

to severer study. It cannot be doubted that no inconsiderable portion of the power and skill of Mr. Binney, Mr. Sergeant, Mr. Chauncey and others who honored the Philadelphia bar, and gave it a wide reputation during the first half of the present century, was due to the fact that at the commencement of their professional life, they were introduced into association with the leaders of the old bar, a body of men who would have graced Westminster Hall in its palmiest days. They may have thought their apprenticeship hard and long, but it yielded abundant fruit.

Mr. Binney was not discouraged by the outlook. With a resolute will, with patient waiting, and with unintermitted devotion to study, he bided his time—and it came. His success in obtaining employment was not speedy. For six years after his admission to the bar, he had a most meager clientage, and, as he remarked afterwards, his porridge would have been very insipid, if he had had to buy salt for it with what he made at the bar. But the time was not lost. He employed it largely in waiting upon the courts, and watching the course of trials, a practice which he afterwards often commended to young men, assuring them that, if attentive, they would learn as much in court as they could in their offices, during the same hours, and that what they learned would be more useful to them in acquiring the art of managing causes.

In April, 1804, he was married to a daughter of Col. John Cox, of Trenton, New Jersey, an efficient officer

in the quartermaster's department during the revolutionary war, and the union thus formed continued through the long period of sixty-one years, until her death.

In the year 1806 he was elected a member of the legislature of the State. He served as such, however, but a single year, declining a re-election. While he was a member, one or two memorials of the Chamber of Commerce and one for the incorporation of The United States Insurance Company were committed to his charge. These brought him into association with the merchants and underwriters of the city, and so satisfactory was his management of the trusts committed to him, that immediately after the close of his membership much professional business relating to insurance flowed in upon him. To Mr. Edward Tilghman, one of the leaders of the "old Bar," he was indebted for his launch into this department of practice. Mr. Binney has himself given an account of his start in his most interesting sketch of three of those leaders. The case committed to his sole charge by the advice of Mr. Tilghman was "Gibson vs. The Philadelphia Insurance Company," reported in 1 Binney, page 405. It was one of difficulty, and it involved the application of principles not familiar to most members of the profession even at the present day. The report shows that it was very ably argued by him, and with success. It was the second case which he argued in the Supreme Court of the State, and it was the beginning

of the large success for which he had waited so long, and for which he had made such thorough preparation. The insurance business was never, perhaps, better, at any time, or at any bar, than it was in Philadelphia, from 1807 to 1817, including the ten years between his substantial entrance into practice, and his attainment of the full reputation and employment which he held undiminished during his continuance in professional life.

In these years, pressingly engaged as he was in professional duties, he prepared and published his six volumes of reported decisions of the Supreme court of Pennsylvania, covering the period from 1799 to 1814. To this work he was invited by Chief Justice Tilghman, soon after his return from the legislature. That he received the invitation from such a source, before he had obtained any considerable practice, and when he was only twenty-seven years old, was a very high testimonial to the confidence which his abilities, his culture, his habits and his character had won for him in the best quarters. Mr. Edward Tilghman's faith in him, as exhibited in the incident to which I have referred, illustrates the respect he had gained from the leaders of the "Old Bar," whose judgment was not likely to err. Of his reports I must make only brief mention. Fortunate would it be for any court of last resort, and fortunate for the legal profession, if all reports had equal merits. Certainly throughout the six volumes the reporter gave irrefragable proofs of his

ability to comprehend legal arguments, and to restate them with clearness in a condensed form. His analysis of the facts upon which the judgments were rendered, was rigid and accurate, and his head notes expressed exactly what the court decided. No complaints have ever been made that his syllabus was not sustained by the case. When the reports came from his hands they left nothing to be desired. They must always be regarded as the work of an accomplished lawyer. It is not an easy matter to report well, and it is very rare that any reporter gives full satisfaction to the court and to the bar. The art requires not merely fairness, accuracy, and ability to comprehend what was argued and decided—it requires all that and more. It demands ability to gather from the mass of facts in the record those that really constitute the case, and to state them lucidly, omitting all that are not material, and overlooking none that are. It demands also power to extract from the opinion of the court the legal principles adjudged to be applicable to the facts, and to restate them in short, and with perfect accuracy. By the universal judgment of the profession, such a reporter was Mr. Binney. His authorship, as a reporter, ceased in 1814 on the publication of his sixth volume.

After 1807 his professional engagements were very large, not only in insurance cases, but in all kinds of important business. He seemed to pass at one bound from his long apprenticeship in waiting into acknowl-

edged leadership. He divided the business of the courts with the eminent men who, when he came to the bar, held all that was worth holding. How great his share became, and how completely he won the confidence of the business community, as well as that of his professional brethren, may, in some measure be discovered by an examination of the reported decisions of the Supreme Court of the State, of the Supreme Court of the United States, and of the Circuit Court of the United States for this district. His work appears in Binney's reports, in those of Sergeant and Rawle, Rawle, Penrose and Watts, William Rawle, in Washington's Circuit Court reports, and in those of Cranch, Wheaton, and Howard. His engagements in the local courts, and in his office were correspondingly large.

He was favored by the privilege of conducting most of his cases, and making most of his arguments in the Supreme Court of the State before a Chief Justice who presided there more than twenty years while he was in full practice, and for whose abilities and personal character he had unbounded veneration, and even affectionate regard. He knew also that he in turn enjoyed the fullest confidence of that most excellent magistrate. The advantage of such relations between an advocate and the court he addresses can hardly be over-estimated. In the Federal Circuit Court for this district, where Judge Washington presided, about thirty years, and in the Supreme Court of the United States under Chief Justice Marshall, he enjoyed similar advantages.

I do not propose to call your attention to any of the cases in which he was engaged, though many of them were of much interest. Grateful as the work would be, I have not time for its performance.

In reference to his arguments, however, I make a single remark. Some of them have been preserved by the reporters in a condensed form. To estimate them justly they should be compared with the condition of legal knowledge and legal reasoning when they were made. And when thus compared, many of them, I think, will be found to have been, in exact exhibition of legal principles, and of the reasons upon which those principles rest, much in advance of what was generally known, and in advance even of what had been expressed in judicial decision.

The war of 1812 brought with it the usual fruits of war: destruction to commerce, embarrassment to trade, rash speculation, and consequent profit to the members of the bar. Unhappily their direct interests are rarely injured by national adversity. This, perhaps, is one of the "principal deductions from the general popularity of the profession, and one of the reasons why it receives more respect than love," without fault of its own. Mr. Binney shared largely in that profit, and the close of the war in 1815, found him in possession of all that the profession of law could give to its professor, whether of reputation or emolument. The eminent leaders of the bar, whom he encountered at his entrance into the profession, had, in a great

degree, retired from active business, and, soon after, most of them departed from life. The field was clear, and, with the exception of Mr. Sergeant and Mr. Chauncey, his constant friends, he was almost without a rival. But this caused no relaxation of his energy. The habits he had formed in college, his love of study for study's sake, and his deep-seated convictions of duty to his clients, with an ever-abiding sense of obligation to them, overcame all tendency to inertness, if any ever approached him, and he continued till the close of his professional life as heartily devoted to it, and as mindful of its claims, as he was in the first flush of his manhood.

He had one cardinal principle upon which he always acted, and which he regarded as the secret of his success. It was to attend to no calling but his profession, knowing that if that were attended to, it would do all for his family and enough for himself. He listened, no, not for a moment, to any invitations, (and many were given him,) to speculate in stocks, or in real estate, or to take part in any kind of trade. He felt it impossible for him to do so without neglecting the practice of the law, which, if faithfully pursued, he was assured would be better than any, or all things else. Guided by this principle he resisted calls to public life. Before he was fifty years old, he had been twice offered a seat on the bench of the Supreme Court of the State, and once, at least, if not twice, he was tendered a commission to be a judge of the Supreme Court of the

United States. All these offers he promptly declined. It was not because he did not value distinction, and not because he did not know his own superior fitness for the posts offered, but he valued excellence above place, and his chosen road to excellence was the path he had marked out for himself at the commencement of his career.

Yet, though he would not suffer himself to be diverted from entire devotion to his profession by office, or by seductive hope of gain in other directions, he did not decline calls that he thought consistent with that devotion. In 1808, when only twenty-eight years of age, he was chosen a director of the first bank of the United States. This appointment he accepted, and he continued to act as a director and a trustee very many years. It was in the service of the bank he argued his first case in the Supreme Court of the United States. The case was The Bank vs. Deveaux et al., reported in 5 Cranch, page 61. No one can read his argument, condensed as it is in the report, without admiring its orderly arrangement, its reach and its logical power. It was the effort of a lawyer well trained and well furnished.

In 1827, Chief Justice Tilghman died. He had in 1806, succeeded Chief Justice Shippen in the headship of the Supreme Court of the State, and he remained its head during the long period of twenty-one years. It was under his administration that the law of the State had grown into an orderly and well adjusted sys-

tem, that the common law of England had been accommodated to the novel circumstances of our people, that the land laws of the State had been reduced to an intelligible code, that our mingled system of law and equity had been developed, and that many of the most important rules of property had been established. To the work of educing such results he was admirably adapted by the structure of his mind and its high culture, by his wise and broad common sense, by the comprehensiveness of his views, by his conscientious devotion to his official duties, and by a purity of character that never bore a spot. He was a man after Mr. Binney's own heart. They were kindred spirits. Under his administration of the law, Mr. Binney had grown into all his greatness and fame, and he felt, as few could feel, how great a debt of gratitude the bar and the state owed to the memory of the deceased magistrate. No wonder then, that, when invited by the bar to pronounce an eulogium of the Chief Justice, he poured out from a full heart, and from the stores of an accurate and discriminating observation, the remarkable discourse contained in the 16th volume of Sergeant & Rawle's Reports. It was not the utterance of respect and affection alone. The discourse exhibits a careful analysis of intellect and character, a just appreciation of what gave to the Chief Justice his power and his usefulness, and an admiring estimate of his moral worth. It is a photograph of that great and good man so life-like that it cannot deceive, so deeply

wrought that it cannot fade, and rendered doubly attractive by the inimitable style in which it was executed.

About the year 1830, after severer exertions than were usual, Mr. Binney's health began to be impaired, and he desired to withdraw gradually from the courts, and throw off, in considerable measure, the load of business with which he was oppressed. It was this, in part, which made him willing to accept a nomination for Congress. There were doubtless other reasons that influenced him. Principal among these was the hostility of President Jackson to the Bank of the United States. His veto of the bill for its recharter in 1832, aroused the deepest feeling of its friends, who then constituted most of the business community of this city. Mr. Binney was one of the number, and his transcendent ability, together with his well-known knowledge of the condition and operations of the bank, pointed him out as the best man to defend the institution in Congress. All eyes turned to him, and his services were at once demanded. Believing as he did in the great usefulness of the bank, and in its necessity for the public welfare, he did not feel at liberty to decline the call. He was elected, and he took his seat as a member of the twenty-third Congress on the 2d of December, 1832. That Congress was filled with distinguished men, many of them, longed trained in the public service. Mr. Binney took into it a great reputation, such as few lawyers ever brought into Congressional life. Much was expected from him, and all

that was expected was realized. If he found any equal, he found no superior. He never stooped to the arena of partisan discussions, but in the consideration of important subjects, especially that of the removal of the public deposits from the Bank of the United States, he proved himself to be a statesman of high rank, and a most accomplished debater. Though but two years a member, he has left at Washington a most enviable reputation. The old men who naturally recur to olden times, speak of him as one of the giants of the past, and worthy to be associated as a statesman and an orator with the triumvirate that so long adorned the American name.

But public life was extremely distasteful to him. He turned his back upon it with gladness "Public reputation," said he, "is generally empty, and oftentimes false, but the respect and affection of one's own kindred and personal friends, ah! that is delightful." Declining a re-election, he returned to Philadelphia, and retired from all professional practice in the courts. In the year 1836 he went to Europe because of the ill health of a member of his family, and only once thereafter did he ever appear in any court as an advocate or a counsellor. He continued, however, to give opinions in his office until 1850. Many of these opinions, written by him, are still in the hands of members of the bar, and they are preserved with almost religious care. They relate to titles to real estate, to trusts and uses, to commercial questions, and to all

questions in every department of the law, that are most intricate and difficult of solution. They are model exhibitions of profound and accurate knowledge, of extensive research, of nice discrimination, and of wise conclusion. They have been generally accepted, as of almost equal authority with judicial decision, and not unfrequently, a claim set up with confidence has been abandoned when it became known Mr. Binney had given an opinion adverse to it.

In the year 1835 he was invited by the Select and Common Councils of the city, to deliver a discourse on the life and character of Chief Justice Marshall. That distinguished magistrate had shortly before gone down to his grave, full of years and of honor, and had left behind him a nation of mourners. He was appointed Chief Justice of the Supreme Court of the United States, by President Adams, in January, 1801, and he continued to preside in that Court during the long period of thirty-four years.

Providence smiled upon our infant nation when he was appointed. The Constitution was then an untried experiment. It had no precedent. It remained to be interpreted, and what principles of interpretation ought to be applied to it, whether a strict or a liberal construction should be adopted, or whether a more rational view should be taken of it, one neither strict nor liberal, but consonant with the paramount intent of those who framed it, and necessary to secure the objects for which it was designed, remained to be determined. It

was quite possible to make a mistake, and mistake might have brought early shipwreck to our institutions. Happily, Chief Justice Marshall proved himself equal to the demands of the time. Aided by associates, themselves able, but who deferred much to his judgment, he laid down principles for constitutional construction which have made our government what it is; which have been accepted since his death without question, and which have given stability and efficiency to the Federal Union. With sufficient knowlege to meet the necessities of his position, with powers of reasoning of the highest order, with a comprehensiveness of view rarely equalled, and with a patriotism that never faltered, he met the questions presented, and did his great work. To use the words of Mr. Binney, "He looked through the Constitution with the glance of intuition. He had been with it at its creation, and had been in communion with it from that hour, * *. Both his judgment and affections bound him to it, as a government supreme in its delegated powers, and supreme in the authority to expound and enforce them, proceeding from the people, designed for their welfare, possessing their confidence, representing their sovereignty, and no more to be restrained in the spirit of jealousy within less than the fair dimensions of its authority, than to be extended beyond them in the spirit of usurpation. These were his constitutional principles, and he interpreted the Constitution by their light." The life and services of such a man were a theme worthy of Mr.

Binney's powers. How well he performed the duty assigned to him, I need not say to the bar of this city who heard him, or who have read his discourse. He performed it "con amore." He knew the Chief Justice well. He accorded with him in his principles, admired his private character, and reverenced his judgments. In him he found powers and principles like his own, and by his eulogy he spread, in clearest light, before those who heard him, the qualities of mind and heart that made the Chief Justice both great and good. He depicted in unfading colors what the great magistrate had done, and held him up to that age and to all future time as an immeasurable benefactor to the country.

In 1844, by appointment of the City Councils, Mr. Binney argued in the Supreme Court of the United States, the case of Vidal *et al. vs.* Girard's executors (reported in 2 Howard, p. 127), in which was involved the validity of the trust created by Mr. Girard's will for the establishment and maintenance of a college for orphans. The case had been argued at a previous term, by Mr. Sergeant, and it is said that, discouraged by the apparent uncertainty remaining in the minds of the judges, he asked for a re-argument. Whether this was so, or not, a re-argument was ordered, and Mr. Binney, though years before he had withdrawn from the state courts, accepted the appointment of the City Councils, and argued the case anew. Of his argument I have no space or time to speak as it deserves. The

remembrance of it lingers around the court room until this day. It is in print, and it has ever been the wonder and the admiration of the legal profession in this country, and almost equally of the profession in Great Britain. It lifted the law of charities out of the depths of obscurity and confusion that covered it before, and while the fullness of its research and the strength of its reasoning were masterly, it was clothed with a precision and beauty of language never surpassed. No wonder it was successful. It was a fitting close to a long and pre-eminent professional life. Mr. Binney never afterwards appeared in court, though he continued for some years to examine legal questions submitted to him, and to give written opinions. At length the calls upon his attention became so numerous as to be oppressive. The examinations they required were trying to his eyes, which after 1832, frequently suffered from inflammation. For these reasons, in 1850, he withdrew entirely from all professional labor. Thus relieved, his eyes recovered their strength, in good measure, and they continued to be of service to him ever after.

But, with leaving the profession, he did not abandon his habits of study. Released from the demands of a jealous and laborious pursuit, he turned with new zest to what had ever been to him a delight. He always had a vigorous appetite for the best literature, especially for that which was moral and religious, and this appetite increased as he grew older. He was a good

Spanish scholar, and proficient also in the French language. Books in both French and Spanish he was fond of reading, as also History, Metaphysics, Poetry (especially dramatic poetry), and Theology. Of the latter subject he was a close student. He was a firm believer in the truths of divine revelation and an habitual reader of the Bible. He carefully read also many of the most important opinions of the Supreme Courts of of the State and of the United States, and some English decisions. He kept himself well informed of the current events of the day, and in regard to all public questions that agitated the city, the state, or the country, he not only sought information, but he matured settled opinions. To such employments he devoted mainly his time and attention after his complete retirement from professional life. Many years afterwards, when speaking of this period of retiracy, he said "his objects had been, *first*, to keep himself from rusting out by such occupations intellectual and bodily as would keep him in reasonable tune, while the decays of age were gradually impairing the old sounding board, *second*, to continue useful to his family, as it was arriving at years of maturity, and would look for settlement in the world, *third*, to be useful to the world, so far as should be in his power, without becoming denatured, by a public part in the various avocations, religious, literary, social, political, philanthropical, national and municipal which distinguished the times from those which preceded them, and, *fourth*, to prepare for the

final event, by availing himself of all the means which God had graciously vouchsafed to him." "Progress in this sense," he added, "is private, public, temporal, eternal;" "spreads undivided, operates unspent," "comprehends the performance of all duties in such measure as is consistent with all, and ends in that perfect stature which all should endeavor to obtain, though so few attain to it."

The activity of his mind remained undiminished until his death. He was constantly occupied, though not always, in the indulgence of his fondness for reading and study. Occasionally he made a rich contribution to the enjoyment and instruction of the public. In 1849, at a meeting of the members of the bar, convened after the death of Mr. Chauncey, and at a similar meeting in 1852, soon after the decease of Mr. Sergeant, he gave utterance to his estimate of those distinguished men, with remarkable analyzation of their mental and moral characteristics, and in words all aglow with the warmest friendship. The meeting in reference to Mr. Sergeant's death was the last occasion of his distinctive association with his professional brethren. He never again appeared at a bar assemblage. Once only afterwards, (so far as I have learned,) did he allow himself to be prominent on an entirely public occasion. It was on the 22d day of February, 1860, when in response to an invitation of the City Councils, he read before those bodies assembled in joint meeting, Washington's Farewell Address. In

addition to the members of the Councils, a few invited friends were present. Mr. Binney, then eighty years of age, stood on the platform in the Common Council chamber, and read the entire address, with a firm voice, and with expressive emphasis. When he had concluded, silence ensued in the chamber, the audience evidently expecting some remarks from him. He was much affected, and after pausing awhile, he said, "and thus closes the noblest compendium of fatherly affection, patriotism and political wisdom the world has ever seen. No words of mine are fit to stand beside it." In the year 1852, at the one hundredth anniversary of The Philadelphia Contributionship for the insurance of houses from losses by fire, he delivered an address on the history of fire insurance, and upon the principles adopted by that association. Like everything which came from him, the address exhibited the completest understanding of his subject, great felicity in its mode of presentation, and a vigor and beauty of expression unsurpassable. It is read with pleasure and with profit even now. In the following year he published a valuable and suggestive article on the naturalization laws. In 1858 he gave to the public a sketch of the life and character of Bushrod Washington, a Judge of the Supreme Court of the United States, who for many years presided in this circuit with great honor to himself, and usefulness to the country. In his court, Mr. Binney had very constantly appeared, in the conduct of most important causes, and there had

grown up between the Judge and the lawyer mutual regard, and even affectionate admiration. These feelings and sentiments found unrestrained expression in the sketch, and therein also, he delineated, with his wonted acuteness, the qualities which make up a perfect *nisi prius* judge, nowhere else better, if as well, described.

In the same year (1858) he published those exquisite descriptions of three leaders of the old bar of Philadelphia, which are still read in this community with intense interest, though the men described belonged to a generation long gone past. The freedom of the writer from all envy or jealousy; the generous appreciation and acknowledgment of true and varied excellence; the searching analysis of intellect and character, and the graceful presentation of each subjects individuality which the descriptions exhibit, have compelled admiration alike in this country and in England where they were reviewed by Sir John Coleridge, with expressions of warm admiration alike of the sketches, and of the author.

In 1858, also, he gave to the press a more extended discussion, entitled "An inquiry into the formation of Washington's farewell address," which is not only curious and interesting, but strikingly illustrative of the character of his mind, and of his habits of thorough investigation, and of reasoning. It is mainly a treatment of evidence, coupled with a description of conflicting probabilities. From it one who never knew him in the

exercise of his profession, may learn how careful and minute was his search after facts, how calmly and wisely he arranged every fact discovered in its proper relation to all others, giving to each its due weight, how inevitably his deductions seemed to flow from his premises, and how precise and perspicuous was the language he employed. No one, I think, can rise from its perusal without a thorough conviction that its conclusions are absolutely correct, and that the opinions that prevailed before its publication were, all of them, more or less, erroneous.

One other product of his thoughts he gave to the public. During the progress of the civil war, the President of the United States, under the pressure of what seemed a real necessity, suspended the privilege of the writ of *Habeas corpus*, without any authority given by Congress, claiming that by the Constitution, and from the nature of his executive office he was invested with the power to suspend the privilege, in cases of rebellion or invasion. As might have been expected, his act immediately called forth much unfavorable criticism, and his power to do what he did, in the absence of Congressional authority, was in many quarters, strenuously denied—in all quarters, perhaps, at least doubted. It was then (in 1862) that Mr. Binney turned to the consideration of the subject, and gave to the public an argument in support of the power claimed by the President, not less remarkable than the best of his earlier efforts. This is not a proper occasion to pronounce

judgment upon the correctness of his conclusions. Of the argument itself, however, I may speak. It was thoroughly original, and it was constructed with a force and elegance that won admiration, even where it did not command assent. It is contained in three pamphlets published successively in 1862, and 1863. They will never cease to be regarded as models of acute reasoning applied to constitutional law.

To such labors and employments Mr. Binney devoted the later years of his life. They were happy years, crowned with habitual cheerfulness, though not unmingled with sorrow. In 1865 Mrs. Binney, his companion through all his early struggles at the bar, and through the period of his highest success, was removed by death. And in 1870 he suffered another severe affliction in the death of his oldest son, Horace Binney, Jr. That son was himself pre-eminent in mental and moral culture, in soundness of judgment, in refinement of taste, in goodness of heart, in true piety, and in all that adorns and ennobles human nature. The father and the son were companions to each other, kindred in spirit as well as in blood. Their mutual confidence was perfect, and consequently their intercourse with each other was a source of intense happiness to both. This was but a natural result of the attention the father had given to the son's training. During the four years the latter was in college, the closest intimacy was kept up between them by a weekly, and at times, a semi-weekly correspondence, in which the father encouraged the

son to perfect confidence in him, and in return gave the benefit of his counsel with a loving interest. The correspondence was never permitted to flag, though Mr. Binney was then at the height of his professional practice, bearing a heavy pressure of business both in and out of court, and superintending a large class of law students, whose examinations he always conducted with regularity and strictness. It was guided by his advice, and in the light of his example and character that the son grew into full manhood, and in the later years of his life the relations between him and his father became more than filial and paternal. They were almost fraternal. The father leaned upon the son, reposed full confidence in him, regarded him as his strongest earthly prop, and looked to him as the one to fill his place after his own last summons should come. How great the sorrow which the son's unlooked for removal, in the fullness of his usefulness, and of the high estimation in which he was held by the community, must have brought to the father's heart cannot be told. Mr. Binney was then more than ninety years old. The shock of such a bereavement might well have been fatal. But the blow did not crush him. He felt it most keenly, but with submission to the will of Divine Providence, he resolutely addressed himself to the new and unexpected duties cast upon him. These having been performed, with his attention more and more turned toward the final event that awaited him, and with a cheerfulness of dis-

position that knew no abatement, he continued to live in the midst of his books and his thoughts, the delight of his family, and the charm of all those who enjoyed intercourse with him until the 12th day of August 1875, when he peacefully passed from this life into a world where his splendid intellectual powers will forever expand, and where his moral excellence will never cease to grow.

His death occurred forty years after the age when most men are at the zenith of their reputation; forty years after he had substantially withdrawn from public view and from active participation in all matters that attract general notice, and at the end of a period when public recollection of most lawyers has faded into indistinctness, yet it would be difficult to mention a death that caused a sensation more wide spread and profound than his. Not alone in this city, or in this state was it felt that a great luminary had been extinguished, but the legal profession of the whole country acknowledged the bereavement, and many unprofessionals hastened to declare their loss.

I have thus given an outline of the life and labors of this remarkable man. In looking over it I see there is much that ought to be filled in, and some things that deserve particular notice.

He was a most accomplished lawyer. This, perhaps, might have been expected from his mental endowments, and from the habits of study that he acquired in early life. But he surpassed expectation. I

know of no language which so aptly describes him as that which he applied to Mr. Edward Tilghman, the friend of his youth: "He was an advocate of great power; a master of every question in his causes; a wary tactician in the management of them; highly accomplished in language; a faultless logician; a man of the purest integrity and the brightest honor; fluent without the least volubility; concise to a degree that left every one's patience and attention unimpaired, and perspicuous to almost the lowest order of understanding, while he was dealing with almost the highest topics."

He had great advantages, none of which were neglected. Besides the opportunities his collegiate course afforded him, and which he improved to the uttermost, besides the art and habit of study he early acquired, he had examples of excellence before him which it was not in his nature to disregard. He was trained to be a legal tactician by his constant attendance in the courts before he was called to assume the management of causes. He thought logically and spoke and wrote the purest of English before he came to the bar. He had a fine commanding person, an uncommonly handsome face, a dignified and graceful manner of address, and a most melodious voice, perfectly under his control, and modulated with unusual skill. He was constitutionally an earnest man, yet while earnest, he had a calm self-possession, the fruit of consciousness that he fully understood his subject, and of confidence that he could make

others understand it, and he entered upon the trial of his causes with a sure conviction, confirmed by his previous study, that he was advocating the right. No unjust or dishonest case would he willingly undertake, and he was able to say after his career at the bar had closed, that "he had never knowingly committed an injustice toward a client, or the opposite party, or prosecuted a cause that he thought a dishonest one, and that he had washed his hands of more than one that he had discovered to be such after he had undertaken it, as well as declined many which he perceived to be such when first presented to him." Add to this the power of a mind equal to the comprehension of any legal subject; a mode of presentation the best possible; a rhetoric that was faultless; an aptness of illustration that illuminated the most abstruse matters; a personal character without a visible flaw, and it is easy to see he must have been, as he was, a most persuasive and convincing advocate.

He won the confidence of courts and juries by his entire freedom from trick, or any of the low arts of cunning. He disdained to practice any stratagem or artifice for the purpose of obtaining an advantage over an adversary. His nature was true, and his life was truth unfolded. He was always candid, giving full consideration to whatever made against him. He appealed to no prejudices, but rather boldly met, and endeavored to dissipate them. He was ever courteous in his demeanor towards the court, and towards his op-

ponents. Thus every element of power, in mind, in culture, in habit, in physical endowment, in taste, in demeanor, and in character, was his. All united in giving to his forensic efforts an efficiency, and a success inferior to those of no other. Our brethren that remain, who saw him at the bar, speak of him as ever maintaining a dignified decorum, and a manner not reserved or cold (though perhaps apparently such at times), but genial and good humored toward his professional brethren, and respectful to the bench. They speak of him as above the suspicion of rhetorical arts, or partisan strategy. They say his appeals were to the judgment rather than to the passions; that his action was graceful; that he never sought to make a display of oratory though he was always eloquent in thought, and winning in diction. He was never heard without instruction, never without pleasure.

He had some other characteristics that deserve special mention. In everything he undertook he was thorough to the highest degree. Thoroughness was a habit of his life. He brought it to all his investigations, and he regarded it as a duty never to be slighted. In his view it was criminal to neglect the fullest possible preparation for the trial of every cause committed to his care, or for any opinion he was called upon to give. One of his maxims, often commended to others, and always acted upon by himself was "Work up to power." Whatever came from him was, therefore, the best he could produce, and those who

followed him rarely found any thing that had escaped his notice, or his thought. What he did not make use of was, in his judgment, of no importance, and therefore entitled to no consideration. It was not unnoticed because unknown. And it was never safe to treat as of little worth any position he took. His mind at once seized all the facts and the principles applicable to them, and discarded all that, after careful thought, he deemed immaterial, or inapposite. He was never surprised by any thing against which the extremest vigilance could guard. Hence nothing immature, nothing unfinished ever came from him in argument, or in essay. Nor was he thorough only in his profession. He carried the habit into his general reading, both literary and scientific. Whatever he knew, he knew throughout. No chamber of it, however remote, escaped his exploration. He gathered from every book he read all the thoughts worthy of being preserved, and made them subjects for his own reflection, recurring to them from time to time for renewed consideration.

His reading was so extensive that he made constant use of helps to return to passages which had most interested him. He was therefore a great admirer of a good index. I say index, not digest. His estimate of such an index was expressed in a letter to a friend, written when he had passed his eighty-sixth year, wherein he said: "I must say in reference to indexes generally, that I have come to regard a good book as curtailed of

half its value, if it has not a pretty full index. It is almost impossible without such a guide, to reproduce on demand the most striking thoughts or facts the book may contain, whether for citation, or further consideration. If I had my own way in the modification of the copyright law, I think I would make the duration of the privilege depend materially on its having such a directory. One may recollect generally that certain thoughts or facts are to be found in a certain book; but without a good index such recollection may be hardly more available than that of the cabin boy, who knew where the ship's tea kettle was, because he saw it fall overboard. In truth a very large part of every man's good reading falls overboard, and unless he has good indexes, he will never find it. I have three books," said he, "in my library which I value more than any other three, except the very books of which they are a verbal index; Cruden's Concordance of the Bible, Mrs. Cowden Clark's Concordance of Shakespeare, and Prendergast's Concordance of Milton." The estimate of good indexes thus expressed illustrates how earnest was his search for truth and knowledge, and how reluctantly he let go any of his acquisitions.

Mr. Binney's thoroughness was accompanied by strictly methodical habits. He had a place for every thing and everything had its place. The arrangement of his briefs, of his papers and books, and equally of his stores of knowledge and thought was perfectly systematic. It was this that enabled him ever to pro-

duce on call, the facts of which he had acquired knowledge, and the thoughts he had matured, together with the illustrations needed, and to fortify what he produced by apt quotation of authorities.

Of his judgment, I find it difficult to speak in fitting terms. It seemed to be intuitive, yet its conclusions were cautious deductions of sound reason from a most comprehensive and accurate view of the facts, alike in detail, and as a whole, and from a wise selection of the principles properly applicable to the state of the facts as he found them. He brought to every subject submitted to him the calmest consideration, unbiassed by prejudice or pre-conceived opinions, and he gave true weight to whatever bore upon it. Hence the decisions of his judgment were never narrow, and almost never wrong. He was a most wise and safe counsellor at the bar, and in every circle where his counsel was sought.

He was a man of great moral courage. When he had matured his convictions of the right, he was not to be driven from their avowal by any fear of consequences. He was a resolute and fearless supporter of law and order in the community. When the Kensington riots threatened to uproot the foundations of society in the northern part of the city; when the law was temporarily overthrown, and its officers were powerless to resist the outbreak; when "men's hearts failed them for fear," and many thought only of submission or compromise, he stood firm. He bent not be-

fore the storm. It was he more than any other who inspired confidence. It was he that restored courage to many who were faint-hearted; that gathered around him the virtue and intelligence of the city, and led in bringing back the supremacy of the law. And when, in later years the foundations of our government seemed crumbling away; when civil war threatened the subversion of our cherished institutions; when attachment to party, with very many, prevailed over love of country, Mr. Binney, an old man of more than fourscore, stepped forward, and placed all his influence and the weight of his great name in the scale of a tottering government. Nor was there ever an occasion when high moral courage was demanded, when the city was in trouble and needed a leader and adviser, that he was called upon and failed efficiently to respond. He was often resorted to in seasons of perplexity, and never was application made in vain. Even when not consulted, the friends of good order, and of the right were encouraged by the fact, of which they needed no other evidence than his life, that he would always be found on the side of the just, the orderly, and the true.

Though he was not long in official life, he gave the fullest proofs that he was both a patriot, and a statesman of high order. The evidence is to be found in the opinions he expressed in Congress, and in those which from time to time he gave to the public while he was in private life. He understood thoroughly the organi-

zation and action of both the State and General Governments, and he was familiar with the whole science of constitutional law. He was in the main a conservative, though not averse to healthy progress. According to the division of parties existing soon after the adoption of the Federal constitution, he was ranked as a Federalist. He adopted the views of the constitution held by Washington, Hamilton and Marshall. To these he adhered during his life, and he made no secret of them when they became unpopular. On the 14th of January, 1872, when writing to a friend, he said: "You know I am the residuary legatee of Washington Federalism. I am not, however, without a great many younger men who are *haeredes instituti*, though *post nati*." But, though a conservative, he approved of changes that he thought improvements. He did not think all changes progress, though he recognized that progress means change. He conceded that the advance of civilization demanded a change of laws in many particulars, and of organic law in some. Still he was not a friend to any changes hastily made; changes that might bring evils in their train not less than those they were intended to cure. Not lacking confidence in the masses of the people, he yet thought it a great mistake to subject the judiciary to dependence on a popular vote. With a high estimate of its importance to the stability of our institutions, and to the correct administration of law between man and man, he deprecated every scheme that threatened diminution to its

independence, and tended to drag it down into the mire of party politics. He favored the consolidation of the City of Philadelphia, as tending, in his judgment, to the promotion of good order, and to the general reform of subsisting abuses, and he lent his influence to send to the Legislature the men of "experience in civil affairs, of general knowledge, talents, integrity, moral courage and conscientiousness" through whose agency consolidation was effected.

Immersed as he was all his life in a flood of occupations, and unwilling while he was engaged in the practice of the law, to be diverted from it by any hope of gain to himself, he felt a deep interest in many institutions cherished by the community, and in many of our noblest charities. He was one of the originators of the Academy of Fine Arts, and with forty other members of the bar he signed the articles of association. William Lewis and Judge Tilghman were also among the signers. Mr. Binney was the youngest. He was present at the first meeting in the Hall of Independence, to choose officers, and to launch the constitution of the society, and there he made an address. He was early connected with the Horticultural Society, and he was a member of the Franklin Institute and of the American Philosophical Society. He presided many years over the Apprentices' Library Company. He was long a director of the Pennsylvania Institution for the deaf and dumb, and he was a contributor to the House of Refuge. He felt great interest

in savings institutions, and in all agencies adapted to promote the thrift and comfort of persons in humble life, and he was associated with other public charities. He was also deeply interested in the benevolent institutions of the Church, to which he belonged, giving to them much of his time, his matured wisdom, and his pecuniary support. The most delicate, refined, and unostentatious charities seemed most to enlist his sympathies. He was a member of the corporation for the relief of the widows and children of clergymen in the communion of the Protestant Episcopal Church from 1831, until his death, and much of the time its President. To it, and to all other associations with which he suffered himself to be connected, he gave much more than his name. He gave his sound judgment, his wise counsels, and, whenever needed, his labor and his money. Their records are full of the evidences of his efficient services, and the touching minutes adopted by them after his decease, attest the value of his co-operation, and the strong hold he had upon the reverence and affection of his associates.

Mr. Binney's friendships were warm, and they were lasting. No envy or jealousy interfered to disturb their harmony. If ever broken, it was because his confidence was necessarily withdrawn. His addresses after the death of Mr. Chauncey, and Mr. Sergeant bear witness to the intensity of his affection for those friends, though more than all others, they had been his

rivals, and often opposed to him in the strife of the bar. In the last year of his life he said in a letter to a life-long friend "my wishes for your happiness are as constant as the return of my days." The tenderness of his love for children was remarkable, and it was often demonstrated. His affections never ceased to flow in warm currents towards the descendants of the friends of his youth, and he found some of his choicest pleasures in contributing to their happiness. His letters abound in outgushing sympathy with the joys and sorrows of the young, as well as with those of his older friends.

Of the light he was in his own dwelling, of the wealth of affection he exhibited there, and of his devotion to the happiness and to the mental and moral culture of his children, I will not speak.

He was an admirable conversationalist and correspondent. His mind and his memory were so full of the richest thoughts that they overflowed into his conversation and into his letters of friendship, and his power of expression was so ready and so chaste, his pleasantry was so genial, and his moral sentiments were so pure, that those who enjoyed correspondence with him will ever preserve his letters among their treasures.

It would be interesting to speak of the stores of observation gathered into his memory during his long life, and ready for his recall. He lived more than ninety-five years and a half, longer than any celebrated

lawyer of whom I have knowledge, either in this country, in Great Britain, or on the continent of Europe. He lived with unimpaired mental faculties, and generally in the enjoyment of good health, preserved and confirmed by temperate habits and regular bodily exercise. His adult life extended over the first three quarters of the present century, a period of advance, not of retrogradation. In it the world saw most remarkable changes. Empires rose and fell. Many new kingdoms and governments were established. Constitutional law made wonderful advances, and municipal law was accommodated to an altered condition of human affairs. The mechanical arts made unprecedented progress. New powers and agencies were discovered, more potent than any before known, and applied to daily use. Religious toleration advanced to be an accepted doctrine, and popular education came to be regarded as of inestimable importance. Society in very many particulars, was revolutionized, and civilization achieved greater triumphs than in any former equal period of the world's history. Of all these changes Mr. Binney was an attentive observer. It was not in his nature to be indifferent to them. He not only noticed the progressive changes, but he must have considered their causes, and their probable consequences. He was himself a link that connected the men of the revolution with the present generation. What an ocean of thought the events and changes of his life-time spread out before his declining years! And

how suggestive the memories must have been! But I may not pursue this speculation.

One other and the crowning glory of his life and character remains to be mentioned. He was an earnest Christian. I have already said he was a close student of Theology, a firm believer in the truths of Divine Revelation, and an habitual reader of the Bible. His confidence in the Divine inspiration of the Bible began in his youth, and gathered strength with his increasing knowledge of what it contains. He was a consistent member of the Protestant Episcopal Church, and he carefully trained his children to the reverence and love he had for its liturgy. For many years he was a leading member of Episcopal Conventions, and he made himself greatly useful in them. He was more than a Church member and a Church officer. He carried his religion into his daily life. It was a controlling power in his business, in the formation of his judgments, and in his intercourse with others. It was the basis of his fidelity to his clients, and of his unwillingness to do injustice to opponents. It led to the courtesy of his demeanor, and to his habitual candor. It contributed also to his personal enjoyments. He found great satisfaction in the study of religious books, especially those relating to doctrinal theology. "He loved to bring his reason to the support of his faith, and he delighted in the most cogent arguments in support of Christianity." His mind was at all times a reverent one. He discountenanced, systematically, in

his household, all conversation and every allusion that looked like irreverence on sacred subjects. More than once he brought the fine powers of his mind to the elucidation of Gospel narrative, and on one occasion he charmed his family and near friends by an essay written in his leisure moments, in support of his own view of a much debated religious question. There dwelt within him habitually a serious conviction of personal responsibility, that led to a high estimate of the value of time, and he was rigid in his self-examination. At one time, near the close of his life, when speaking of his debility, he said, "but I do not think that I have gone back, and I am very thankful for it, because a single step backward would, I think, have finished my *sum* and it must have been shown as it stood on the *slate*, right or wrong, to the Great Master I hope that what is wrong in the *sum* may prove to be written on *slate*, that Mercy may pass her soft and gentle hand over it. But there is something which no touch will remove, because it is not *there*—THE GOOD I HAVE NOT DONE."

His faith was a support and consolation to him in the times of his great sorrow. It gave him infinite comfort when his son Horace was removed by death. Indeed the strongest bond of union between the father and the son was, at all times, the assurance they felt of their common confidence and trust in the Triune God, and that trust was the father's anchor when the waves of sorrow went over him. It never failed him. His last days were illumined by a calm reliance upon

his Redeemer, and by a perfect willingness to meet the final summons whenever it might come. Doubtless he was found watching. The books which he read and actually studied during the months of June and July immediately preceding his death were "The Philosophy of Natural Theology," an Oxford Prize Essay, written by the Rev. William Jackson, in confutation of the scepticism of the present day, and "The Unseen Universe," or "physical speculations on a future state," both of them works of deep-toned piety, as well as of great research. They cannot be read without close attention, and intense thought.

I feel that I ought not to detain you longer, though very much of great interest remains unsaid. *After all*, Mr. Binney's powers and character are best illustrated by his life. That was singularly consistent and complete. It is safe to say that rarely if ever, has a man lived who had fewer apparent defects From whatever point of human view he was observed, no flaw or imperfection was visible. In every aspect, he was symmetrical, with no faculty undeveloped or distorted, with not even an excellence overgrown at the expense of any other—throughout both great and good.

Such was Mr. Binney. So during three generations he stood erect and conspicuous among his brethren of the bar, and in this community, a light and an ornament—a strong tower and a ground of trust,—a leader and a guide.

Stated Meeting, January 7th, 1876.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the R. Observatory at Prague, Oct. 13, (92); Bavarian Academy, Nov. 1, (92, 93); Holland Society at Haarlem, Aug. (92); L. and P. Society at Liverpool, Dec. 3, (93, 94); Anthropological Institute of Great Britain, Dec. 15, (XV, ii, 93, 94); and the New York Lyceum of Natural History, Dec. 28th, (XV, ii, 94).

Letters of envoy were received from the C. P. Observatory at St. Petersburg; C. Bureau of Statistics, Stockholm, Sept. 20; Bavarian Academy, Munich, Nov. 1; Haarlem Society, Jan. 20; L. and P. Society, Liverpool, Dec. 3; and Board of Commissioners of the Second Geological Survey of Pennsylvania.

Donations for the Library were received from the Bureau of Statistics at Stockholm; International Congress of Geography of 1875, at Paris; Prague Observatory; Geographical Society and Geological Institute at Vienna; Imperial Academy and Geological Society at Berlin; Zoological Gardens at Frankfort; Holland Society at Haarlem; Dr. Jos. B. Davis; R. Institute of Lombardy; Venetian Institute; Geological Committee at Florence; Academia dei Lincei, and Pontifical Academy at Rome; Observatory at Naples; Anthropological and Geographical Societies at Paris; Annales des Mines; Nouvelles Météorologiques; Revue Politique;

M. L. Hugo; Physical Society at Bordeaux; Astronomical, Chemical and Zoological Societies at London; Nature; Gen. Sabine; Silliman's Journal; Prof. Frederick Prime, Jr.; American Chemist; Penn Monthly; Journal of Pharmacy; Geological Survey of Pennsylvania; U. S. Department of the Interior, and Mexican Geographical and Statistical Society.

A set of photographs of ornaments on the Public Buildings were presented by Mr. McArthur.

The Committee on Dr. Valentini's paper reported progress and was continued.

The death of Dr. Wm. Böckh, at Christiania in Norway, Dec. 10, 1875, was announced by letter.

Prof. Houston communicated his views regarding the so-called "'new force" claimed to have been discovered by Prof. Eddison of Newark, N. J.

The report of the judges and clerks of the annual election was read in its usual form, announcing as the officers of the ensuing year:—

President,

George B. Wood.

Vice Presidents,

John C. Cresson, Isaac Lea, Frederick Fraley.

Secretaries,

E. Otis Kendall, John L. LeConte, Pliny E. Chase, J. P. Lesley.

Curators,

Joseph Carson, Hector Tyndale, C. M. Cresson.

Treasurer,

J. Sergeant Price.

Councilors to serve for three years,

Alfred L. Elwyn, Benj. H. Coates, Benj. V. Marsh,
Geo. H. Horn.

Mr. Lesley was nominated Librarian.

Pending nomination No. 791 and new nomination No. 792 were read.

Mr. Price reported for the Committee on the Eulogium of the Hon. Horace Binney, that it was acceptably delivered on the evening appointed, and that the MSS. was already in the printer's hands.

On motion, the subject of the present condition of the space alongside of the Hall was referred to the Hall Committee for speedy action.

And the meeting was adjourned.

On the Progress of the Museum and Palæontological Work of the Second Geological Survey of Pennsylvania, for the year 1875.

By Charles E. Hall.

(*Read before the American Philosophical Society, January* 15, 1876.)

The principal collections received from the Assistants and their parties have generally been to demonstrate the sections made by them in their particular districts.

The following collections of fossils have been made :

A series of specimens representing a section from Bellefonte, Centre County, to the Allegheny Mountain, including specimens from the Limestone of II up to the Coal Measures. Number of specimens 165. A collection of bituminous and cannel coals, also cokes. By Mr. F. Platt.

A series of specimens representing the horizons of the Mountain and Oil sands with their included measures and fossils from Venango, Warren, Foster and Crawford Counties. By Mr. J. F. Carll.

Specimens from Mifflin County, representing the Logan and Lewistown Sections;—from Graham's, Snyder's and McKees' fossil-ore openings;—McVeytown Section, including Ross's, McCoy's and Dull and Brady's Ore Banks (Marcellus hematite);—Mt. Union Section. Number of specimens 747. By J. H. Dewees.

Specimens from the South Mountain district, including some fossils. By Prof. Fredk. Prime, Jr.

Specimens of sandstone with Scolithus linearis, from Franklin County. By Prof. P. Frazer, Jr.

Collection of Coal Plants from Washington and Green Counties. By Prof. Stevenson and J. C. White.

Collection of Fossils from the Chemung and Catskill, with section through a portion of the Chemung, Tioga County. By A. Sherwood.

Collection of Fossils from the Hamilton Group at Marshall's Falls, Monroe County. By H. Martyn Chance.

Specimens representing a section from the Limestone of II at Orbisonia to the Coal Measures of Broadtop Mountain, Huntingdon County. Number of specimens 350. By C. E. Billin and C. A. Ashburner.

Besides these there have been special palæontological collections made at the following localities during the past summer :

From the Carboniferous in Westmoreland County, and in Washington and Greene Counties.

From the Catskill, in Tioga County.

From the Chemung group, from eight localities in Tioga County.

From the Hamilton group at Marshall's Falls and vicinity, in Monroe

County; at Orbisonia and vicinity in Huntingdon County; and at Bell's Mills in Blair County.

From the Oriskany Sandstone at Orbisonia and vicinity.

From the Lower Helderberg, at Orbisonia and vicinity, and at Mansing's Quarry, Carbon County.

From the Clinton Group, at McKee's ore bank, Mifflin County; at Matilda Furnace, Mifflin County; at Orbisonia, in Huntingdon County; at Bell's Mills, in Blair County; and at Hollidaysburg, in Blair County.

From the Oneida Conglomerate at Port Clinton, Schuylkill County.

From the Utica Slate and Hudson River group; at Bellefonte, Centre County; near Henrietta, Bedford County; at Henrietta, Blair County.

From the Trenton Limestone; in the Kischicoquillas Valley, Mifflin County; at Bellefonte, in Centre County.

From the horizon below the Trenton; at Reedsville, Kischicoquillas Valley, Mifflin County; from near Bellefonte, Centre County; and from near Martinsburg, Blair County.

The following list of genera and species shows the result of the season's work. I have also included those mentioned by Prof. H. D. Rogers in the First Survey, many of which I have been able to recognize in our limited collection. All the species, except those of the Chemung have been collected during the past summer.

UPPER CHEMUNG (*and Waverly*).

Actinocrinus,
Aristozoa,
Bellerophon,
Carina hamiltonæ,
Cyrtina hamiltonensis,
Cystids,
Discina newberryi,
Dithyrocaris,
Euripterus,
Fenestella,
Lepidechinus,
Lingula delia,
Modiomorpha alta.
Orthoceras,
Platyceras,
"
Productella boydii
" costatula,
" striatula,
Rhynconella contracta,
Spirifer alta,
" disjuncta,
Streptorynchus chemungensis.

These specimens are from Warren and Venango Counties, from J F. Carll, and F. A. Randall.

CHEMUNG. (*Vergent, VIII.*)

Athyris angelica,
" polita,
Atrypa spinosa,
Discina newberryi,
Gramnysia,
Productella lachrymosa var. stigmata,
" striatula,
Rhynconella orbicularis,
Spirifer disjuncta,*
Streptorynchus chemungensis,*

* Those marked * are mentioned by Rogers.

Modiomorpha
Orthis impressa,
Productella boydii,
Strophodonta cayuta,
" concava,
" perplana,

The above are from Tioga County.

HAMILTON GROUP. (*Cadent, VIII.*)

Aviculopecten princeps,
Athyris spiriferoides,*
Atrypa reticularis,
Ambocœlia umbonata,
Bellerophon,
Chonetes mucronatus,
" coronata,
Cryptonella planirostra,
Cimitaria recurva,
Discina grandis,
" newberryi,
Dalmania,
Fenestella,*
Gramnysia,
Heliophyllum halli,
Modiolopsis modiomorpha,
Lingula ligea,
Phacops bufo,*
Rensselæria? johanni,
Rynconella dotis,
Spirifer fimbricata,
" granulifera,*
" medialis,*
" mucronatus,*
" sculptilis,
Strophodonta concava,
" rhomboidalis,
Trepidoleptus carinatus,
Tentaculites.

All the above are from Marshall's Falls, Monroe County, Pa.

Rogers, p. 827, gives the following, also:

Atrypa aspera,
Spirifer congesta,
Strophodonta perplana,
Strophodonta demissa,
Trematospira hirsuta,

ORISKANY SANDSTONE. (*Meridian, VIII.*)

Cyrtoceras expansus,
Dalmania micrurus,
Etonia peculiaris,
Megambonia lamellosa,
Orthis hipparionyx,*
Platyceras ventricosa,
Pterinea texilis,
Rensselæria marylandica,
" ovalis,
" ovoides,*
Spirifer arenosus,*
" arrectus.

All these are from the vicinity of Orbisonia.

LOWER HELDERBERG. (*Pre-Meridian, VI.*)

Acevalaria,
Alveolites minima,
Alveolites,
Artylospongia inornata,
Merista lævis,*
Orthis oblata,
Pentamerus galeatus,*
Rhynconella formosa,

* Those marked * are mentioned by Rogers.

Artylospongia,
Atrypa reticularis,
Aulopora,
Conophyllum,
Merista arcuata,
Stromatopora,
"
Trematospira formosa,
Zaphrentis.

All the above are from Aughwick Valley, near Orbisonia.

Rogers, p. 825, gives the following, also:

Etonia peculiaris,
Platyostoma,
Rhynconella nobilis,
Spirifer macropleurus,
" sulcatus,
Strophodonta punctulifera.

NIAGARA, WATERLIME, AND ONONDAGA, OR SALINA. (*Scalent, VI.*)

Rogers, p 824, gives the following:

Bevrichia pennsylvanica,
Leperditia alta,
Tentaculites ornatus.

CLINTON GROUP. (*Surgent, V.*)

Atrypa reticularis,*.....Ferguson and Aughwick valley.
Beyrichia lata,..... " " " "
Buthotrepis gracilis,*..... " " " "
Dalmania limulurus,..... " " " "
Homalonotus delphinocephalus,..... " " " "
Illænus barrienis,.....Ferguson valley, Mifflin county.
Merista intermedia,*.....Bell's Mills, Blair county.
Modiolopsis subcarinatus,.....Ferguson valley.
Orbicula,.....Bell's Mills.
Orthis elegantula,*.....Ferguson and Aughwick valley.
Orthonota curta,..... " valley.
Platyostoma niagarensis,..... " and Aughwick valley.
Pterinea emacerata,..... " " " "
Pterinea rhomboidea,..... " valley
Rhynconella neglecta,..... " and Aughwick valley
" robusta,..... " valley.
Spirifer radiatus,.....Bell's Mills.
Strophomena rhomboidalis,*.....Ferguson and Aughwick valley.
" subplana,*..... " valley.
Strophodonta prisca,..... " "

ONEIDA CONGLOMERATE AND MEDINA SANDSTONE. (*Levant, IV.*)

Arthrophycus harlani.* Mifflin and Schuylkill Counties.

Rogers, p. 822, gives the following, also:

Bucania trilobatus,
Lingula cuneata.

* Those marked * are mentioned by Rogers.

UTICA SLATE AND HUDSON RIVER. (*Matinal, III.*)

Chætetes lycoperdon,	Canoe valley.
Glyptocrinus decadactylus,*	" "
Graptolithus,	" "
Strophomena,	" "
Triarthrus beckii,*	Nittany valley.

Rogers, p. 818, gives the following, also :

Agnostus lobatus,	Lingula quadrata,
Ambonychia bellistriata,	Modiolopsis modiolaris,
" radiata,	Murchisonia gracilis,
Avicula insueta,	Orbicula,
Bellerophon bilobatus,	Ormoceras crebriceptum,
Conularia trentonensis,	Orthis lynx,
Cyrtolites ornatus,	Orthoceras vertebrale,
Endoceras proteiforme,	Pleurotomaria bilix,
Graptolithus pristis,	" subconica,
Heterocrinus,	Rhynconella increbescens,
Lingula curta,	Stictopora acuta.

TRENTON LIMESTONE. (*Matinal, II.*)

Calymene senaria,.....Nittany valley.
Chætetes lycoperdon,* ..... " and Kischicoquillas valley, and Northampton county.
Crytoceras trentonensis,.....Nittany valley.
Dalmania gigas,* ..... " "
Eschapora recta,.....Kischicoquillas valley.
Leptæna sericea,* ..... " and Nittany valley.
Lingula riciniformis,.....Nittany valley.
Orthis testudinaria,* .....Nittany and Kischicoquillas valley.
" tricinaria, ... " valley.
" pectinella,* .....Northampton county.
Stictopora elegantula, ...Kischicoquillas valley.
Strophomena alternata,*.....Nittany and Kischicoquillas valley.
" deltoidea,.....Nittany valley.
Trinucleus concentricus,*..... " and Kischicoquillas valley.

BLACK RIVER LIMESTONE. (*Matinal, II.*)

Chætetes lycoperdon, ...Canoe valley.
Gonioceras anceps, ... " "
Murchisonia angustata, ...Kischicoquillas valley.

* Those marked * are mentioned by Rogers.

Orthoceras multicameratum,*.....Canoe valley.
Pleurotomoria umbilicata,*..... " "

Rogers, (p. 817) mentions the following, not as yet observed :

Euomphalus ungulatus,	Ophileta levata,
Maclurea matutina,	Pleurotomaria nucleolata,
" magna,	Pleurotomaria turgida,
Murchisonia bicincta,	Retapora staminea,
Leperditia ovata,	" striata,
Orthoceras tenuifillum,	Rhynconella plicifera.

CHAZY LIMESTONE. (*Matinal, II.*)

Asaphus canalis,*.....Kischicoquillas valley.
" marginalis,..... " "
Orthis costalis,..... " "
Orthoceras, ... " "
Strophemena incrassata,*..... " "

LOWER LIMESTONES. CALCIFEROUS. (*Auroral, II.*)

Asaphus,.....Nittany valley.
Euomphalus,.....Canoe valley.
Illænus, ...Nittany valley.

POTSDAM SANDSTONE. (*Primal, I.*)

Scolithus linearis,.....Lehigh and Franklin counties.

In the above list no mention is made of the organic animal remains of the Coal Measures, no collections in these having been as yet systematically made. Those observed by Prof. J. J. Stevenson in Washington and Greene Counties will be recorded in his forthcoming report of 1875.

An important collection recently sent in by Mr. Carll has not yet been sufficiently studied to be included in the present notice.

* Those marked * are mentioned by Rogers.

Contributions to the Physical Geography of the United States, by Charles Allen, Assistant in charge of the Collection and Collation of Railroad and other Levels for the Second Geological Survey of Pennsylvania.

By J. P. Lesley.

(*Read before the American Philosophical Society, January* 15, 1876.)

In presenting to the attention of the members Mr. Allen's list of Pennsylvania levels, I have only to say that the progress of physical geography in the United States has been so rapid, of late years, as to attract the attention of the Scientific world at home and abroad, and that its connection with the progress of geological science is so intimate, that working geologists hail with lively pleasure the publication of all hypsometrical records of a genuine kind, whether old or new. For want of government bureaus of statistics the greater part of such records have been irrecoverably lost. Of the tentative work of our railway, canal, slackwater and turnpike companies, done between 1830 and 1860, scarcely a trace remains; although, if its records could be recovered and printed, they would furnish copy for hundreds of volumes. Since 1860 the destruction has not been so complete, but has been nevertheless very great. There are recent important surveys of which no records can be found, even in the offices of the companies for whom they were made.

This important subject has received well-deserved attention at the hands of the chiefs of the United States Exploring Expeditions, who are mapping the interior of the Continent. But some efficient organization is required for the preservation and publication of levels in the States lying between the Atlantic and the Mississippi.

The State Geologists of Ohio and North Carolina, also, have published valuable hypsometric tables.

A beginning has now been made in Pennsylvania; and the following pages contain the records of the height above some assumed datum, reduced to tide level, of all stations on railways in the State, and in its immediate vicinity.

These records have mostly been obtained by personal examination of the profiles preserved at the offices; and in some cases, by letter, from superintendents and engineers. The greatest interest in the Collection has been manifested by members of the profession of Civil Engineering to whom application has been made; and in some instances, where records were wanting, new levelings have been ordered and the results transmitted.

Short headings are prefixed to the records, stating place, date and authority; and foot notes appended to them, stating difficulties of adjustment, incongruities, or doubts.

That a work of this nature should have the advantage of first publication in the transactions of the oldest Scientific Society of America, whose first President was Benjamin Franklin, and whose hall stands side by side with the ancient Capitol of the United States, is my reason for asking that this first systematic attempt on a large scale to render permanent and useful to all engineers and surveyors the scattered and perishable records of heights above sea-level of several thousand points in our valleys and on our mountains should be accepted by the Society.

It must be understood, however, that these lists require thorough re-examination and correction before they can be adopted as constants of science for the future. There are considerable difficulties yet to be encountered by such as undertake to harmonise the data of our railway surveys. Indeed, considering the imperfect way in which such surveys are necessarily made,—the accumulation of errors of instrumentation and personal equation along every long spirit-level line,—the uncertainty even of the tide-level datum at every head of tide,—the frequent lack of notes stating whether railway levels cross each other on grade, or not,—and the not uncommon fact that, after location-surveys have

been made, the road-beds have been tempered up, or down, to suit convenience, and no record of the fact been kept, except in the memory of some division engineer no longer in the employ of the Company,—it is surprising that the errors of terminal or crossing adjustment are so few and small. But to render the record perfect all such errors, however few and small, must be eliminated; and this can only be accomplished by a zealous interest taken in the subject by resident engineers; who are therefore earnestly requested to co-operate to this end.

Geologists are dependent for the goodness of their field-work on accurate base-line levels. And it is to be hoped that a complete exhibition of the surface contour of Pennsylvania will sooner or later be obtained from a collation of the thousands of transit-lines and barometer-lines now in progress in all the districts occupied by the Assistant Geologists of the Survey. All their lines of levels are, however, based on the railroad records, and the publication of these in a corrected form is a necessary preliminary step.

If movements are still taking place in the crust of the earth,—and the frequent occurrence of slight earthquake shocks, in all the States of the Union, seems to speak in favor of the supposition,—physical philosophers are peculiarly interested in an early establishment of a universal hypsometrical record. From this point of view, also, it would seem especially germain to the origin and history of the American Philosophical Society to initiate such a record.

The net-work of Surveys which cover Pennsylvania may be divided into nine systems:

1. The Pennsylvania Central east and west system, from Trenton through Philadelphia, Harrisburg, Altoona, Pittsburgh, to Steubenville, and Youngstown, in Ohio; with numerous longer or shorter side branches.

2. The Reading Railroad northwest and southeast system, with many short branches in the Schuylkill Anthracite Field, and through the country in front of it between the Delaware and Susquehanna Rivers. It has been extended also to the

waters of the Upper Susquehanna, and will penetrate into New York State.

3. The North Pennsylvania north and south system, with numerous branches in the Lehigh and Wilkesbarre Anthracite Fields, in connection with the two Lehigh Valley Railroads, extending into the State of New York.

4. The Northern Central north and south system, extending from Baltimore, in Maryland, to Elmira, in New York, with several short branches.

5. The Philadelphia and Erie northwest system, with important branches crossing to the Alleghany River, and into the State of New York.

6. The Alleghany River north and south system, from Pittsburgh to the Oil Region, and Buffalo in New York.

7. The Baltimore and Ohio system, with its Connellsville branch to Pittsburgh, and its short coal and coke branch.

8. The Beaver River system, north and south, along the western margin of the State.

9. The Philadelphia, Wilmington and Baltimore southwest system.

The following tables are arranged in the above order, and will explain themselves:

I. The Pennsylvania R. R. System.

1. Pennsylvania Railroad.

Note.—The elevations at the various stations, on the Pennsylvania Railroad, were copied from the Engineers' notes, by permission of Mr. W. H. Wilson, its Consulting Engineer.

The datum, or base of levels, is ordinary high-water in Schuylkill River. This datum, according to Mr. James T. Gardener's determination, is 6.913 feet* above mean surface of the Atlantic Ocean. *These 7 feet are added in the second column.* Decimal parts of a foot do not occur in these lists. When below .5 they have been omitted; when more than .5 a whole number has been substituted.

* Permanent U. S. Coast Survey granite bench at Gloucester Ferry, N. J., opposite Philadelphia, is 8.10 above Mean Tide Raritan Bay, or Mean Ocean level. Mean Tide Delaware River = 8.10 — 4.751 = 3.349. Philadelphia City Surveyor's datum: 8.10 — 0.632 = 8.732. Pennsylvania R. R. Engineer's datum: 8.10 — 1.819 High tide, 6.913.

Pennsylvania R. R. Main Line.

STATIONS.	High Tide, Philad'a.	Above mean level Atlantic Ocean.
Philadelphia, Market Street	25	32
West Philadelphia	27	34
Powelton Avenue	38	45
Fairmount Bridge	44	51
Mantua	94	101
Belmont Avenue	103	110
Hestonville	136	143
City Avenue	214	221
Merion	240	247
Elm	278	285
Wynnewood	308	315
Ardmore	352	359
Bryn Mawr	409	416
Rosemont	388	395
Villa Nova	423	430
Union	423	430
Radnor	402	409
Edgewood Avenue	394	401
Wayne	398	405
Reeseville	488	495
Paoli	527	534
Green Tree	536	543
Malvern	539	546
Fraser	483	490
Glenlock	446	453
Ship Bridge *	404	411
Walkertown	381	388
E. B. & W. R. R. See Tab. II.	248	255
Downingtown	259	266
Gallaghersville	291	298
Thorndale	306	313
Cain	352	359
Coatesville (W. & R. R. R.) Tab. LVI.	373	380
Midway	387	394
Pomeroy. P. & D. R. R. Tab. III.	476	483
Chandlers	482	489
Parkesburg	530	537
Summit †	551	558
Penningtonville	493	500
Christiana	484	491
Summit ‡	566	573
Gap	552	559
Kinzers	461	468
Spindlers	397	404
Leamen Place	375	382
Gordonville	378	385
Fairview	378	385
Bird in Hand	352	359

* Intersection of Waynesburg Branch.
† West of Parkesburg.
‡ East of Gap Station.

STATIONS.		High Tide, Philad'a.	Mean Tide Atlantic Ocean.
Lancaster ‡		352	359
Dillerville Junction ‖	Columbia Line.	352	359
Rohrerstown §		345	352
Mountville		397	404
Columbia		244	251
Chiquies		248	255
Marietta		253	260
Shocks Mill		262	269
Bainbridge		264	271
Collins		278	285
Middletown Junction (*a*)		307	314
Landisv'e R.&C.R.R. (*b*). Tab. LVII		398	405
Salunga		396	403
Chiquies Bridge		344	351
Mount Joy (*c*)		359	366
Springville		383	390
Reams		432	439
Tunnel		472	479
Elizabethtown		450	457
Conewago		422	429
Middletown		307	314
Highspire		293	300
Harrisburg *		313	320
Susquehanna		335	342
Susquehanna Bridge		343	350
Marysville		343	350
N. C. R. R. Crossing † Tab.		342	349
Duncannon		349	356
Aqueduct		370	377
Bailys		380	387
Newport		388	395
Millerstown		401	408
Thompsontown		412	419
Tuscarora ¶		422	429
Mexico		426	433
Perryville		434	441
Mifflin		434	441
Black Log		455	462
Bixlers		475	482
Lewistown		491	498
M. & C. C. R. R. Crossing ‖‖ Tab. V.		492	499
Granville		491	498

‡ Bench Mark on Stone Wall, Lancaster Locomotive Works, 339.

‖ Junction of Columbia Branch, at Dillerville.

§ On Columbia Branch.

(*a*) Junction of Columbia Branch, at Middletown.

(*b*) Reading and Columbia R. R. Crossing, at Landisville.

(*c*) East side of R. R. Hotel.

* West line of depot 313.91. Curb stone at lamp post U. S. Hotel 313.54. West line of Lebanon Valley Depot 315.5. West line of State street 319.2.

† Northern Central R. R. Crossing.

¶ Bench Mark on top of Stone foundation west corner of Water Station 424.44.

‖‖ Junction at Mifflin and Centre County R. R.

STATIONS.	High Tide, Philad'a.	Mean Tide Atlantic Ocean.
Anderson's	493	500
Anderson's. Water Station	492	499
McVeytown	515	522
Manayunk	512	519
Vineyard	541	548
Newton Hamilton	592	599
Mount Union. § E. B. T. Tab. VII.	590	597
Jackstown	588	595
Mapleton	586	593
Mill Creek	597	604
Huntingdon.* H.& B.T.Tab. VIII.	615	622
Warrior Ridge	670	677
Petersburg	671	678
Sherman's Bridge †	692	699
Barre Forge	717	724
Tunnel ‡	754	761
Spruce Creek	770	777
Union Furnace	792	799
Birmingham	859	866
Tyrone Water Station	889	896
Tyrone R.R. Tables XIII.XIV.XV.	900	907
Tipton	983	990
Fostoria	1022	1029
Bells Mills R. R. Table XVIII.	1053	1060
Elizabeth Furnace	1072	1079
Blair Furnace	1107	1114
Altoona ‖ R.R.Tables XIX.–XXIII	1171	1178
Kittanning	1587	1594
Murdocks	1619	1626
Alligrippus	1913	1920
Bennington Furnace	2031	2038
Tunnel ¶	2119	2126
Gallitzin	2154	2161
Cresson (*a*) E.&C.R.R.Tab. XXIV.	2010	2017
Lillys	1880	1887
Portage	1668	1675
Wilmore	1550	1557
Summit (*b*)	1562	1569
Summerhill	1550	1557
South Fork	1477	1485
Viaduct (*c*)	1449	1456

§ Junction of East Broad Top R. R. (narrow guage).

* West line of ticket office, crossing south track west to Huntingdon & Broad Top R. 613.9.

† Bench Mark on west end of bridge.

‡ West end of Spruce Creek Tunnel.

‖ West line of ticket office 1171. B. M. (Bench Mark) south-west corner, top step front door of ticket office 1174.

¶ B. M. at east end of Tunnel, on rough part of first course of stone above foundation.

(*a*) Switch to Ebensburgh and Cresson R. R. 2021.

(*b*) Pringles point.

(*c*) Bench Mark on N. W. corner west end of coping.

STATIONS.	High Tide, Philad'a.	Mean Tide Atlantic Ocean.	
Mineral Point	1407	1414	
Conemaugh	1218	1225	
Johnstown	1177	1184	
Sandy Hollow	1136	1143	
Conemaugh Furnace	1128	1135	
Nineveh	1134	1141	
New Florence	1069	1076	
Houstons	1049	1056	
Lockport	1047	1054	
Bolivar	1026	1033	
Blairsville Junction * Tab. XXV.	1106	1113	
Hillside	1122	1129	
Millwood	1148	1155	
Derry	1165	1172	
Lindorff's Summit	1178	1185	
St. Clair { Lig. R.R. Tab. XXIX.	1085	1092	
Latrobe { Lig. R.R. Tab. XXIX.	999	1006	
Beatty's	1066	1073	
Kearney's †	1041	1048	
Shanghai	1166	1173	
Carr's Tunnel ‡	1201	1208	
George's	1199	1206	
Greensburg ‖ S. W. P. RR. Tab. XXX.	1084	1091	
McGrau's Tunnel §	1156	1163	
Radebaughs	1143	1150	
Grapeville	1052	1059	
Penn	967	974	
Manor	935	942	
Shafton	893	900	
Irwin's. Y. R. R. Table XXXI.	877	884	
Larimer's	859	866	
Carpenter's	847	854	
Stewart's	784	791	
Wall's	744	751	
Springhill	742	749	
Turtle Creek	743	750	
Oak Hill	743	750	
Brinton's	750	757	
Braddock's	821	828	
Copeland	846	853	
Hawkins'	876	883	
Swiss Vale	915	922	
Edgewood	916	923	
Wilkinsburg	916	923	
Brushton	915	922	

* Intersection of Blairsville and Indiana Branch of Pa. R. R. with main line.

† Rogers' Summit 1201.8.

‡ East face of Tunnel.

‖ B. M. east face of Greensburg Tunnel on top of rough part of second course from bottom 'R' 1079.52.

§ West face of tunnel.

STATIONS.	High Tide, Philad'a.	Mean Tide Atlantic Ocean.
Homewood	916	923
Torrens	913	920
East Liberty	911	918
Roups'	875	882
Shadyside	859	866
Millvale	826	833
Lawrenceville	773	780
Pittsburgh *	738	745

II. East Brandywine Railroad.

NOTE.—The levels on the East Brandywine and Waynesburg R. R. were furnished by Mr. W. H. Wilson, Consulting Engineer of the Pennsylvania R.R.

The datum, or base of levels is ordinary high water in Schuylkill River, Philadelphia. Therefore 7 *feet are added in the second column to reduce to mean tide in the Atlantic Ocean.*

STATIONS.	High Tide, Philad'a.	Ocean Level.
Downingtown Terminus. † Table I.	249	256
Shelmeirs	239	246
Dowlin's Forge	271	278
Dorlan's	273	280
Reed's Road	302	309
Brooklyn	329	336
Cornog's	354	361
Springton	398	405
Moorestown	436	443
Barnestown	479	486
Lewis Mills	535	542
Cupola	556	563
Forrest	564	571
Dampman's	624	631
W. & R. R. R. ‡ Table LVI.	666?	673?
Buchanan's	665	672
Lancaster Pike	689	696
Waynesburg	721?	728?
End of Track	734	741

* West face of Union Passenger Depot, east side of Wayne Station 734.5. East side of Irwin street 729.7. East side of Duquesne street depot 725.4. Bench Mark at foot of lamp post south side of Liberty street, intersection with Water street 721.27.

Bench Mark on south side of base ring, of fire plug, north side of Penn street, intersection with Water street, 719.

† Junction with north track of the Pa. R. R. near Downingtown.

‡ Crossing Wilmington and Reading R. R.

III. Pennsylvania and Delaware R. R.

NOTE.—The elevations on the Pennsylvania and Delaware Railroad were obtained in the office of Mr. George W. Leuffer, C. E., of Philadelphia.

At Pomeroy Station, 43 miles of Philadelphia, this road joins the Pennsylvania R. R. Mr. Leuffer makes this point 472.9; Mr. Wilson 476.039. To Mr. Leuffer's levels in the first column are therefore added 3 feet to accord with the P. R. R. list, and an additional 7 feet to reduce to mean Atlantic tide level.

STATIONS.	High Tide, Philad'a.	Ocean Level.	
Pomorey Junction * Table I.	472.9	483	
Doe Run	364	374	
Pusey's Summit	460.	470	
Pennock's Summit	453	463	
Avondale ** Table	271.6	281.6	
Newark †	108	118	
Delaware R. R. Crossing ‡	76.2	86.2	
Delaware City	6.	16	

IV. York Branch P. R. R.

The levels on the York Branch of the Pennsylvania R. R. were copied from the profile in the office of the P. R. R. at Philadelphia.

In accordance with instructions of Mr. W. H. Wilson, 3′ was added to each elevation, as shown on the profile, in order to agree with the level of Columbia according to Pa. R. R.; and also 7 feet to reduce to mean Ocean level.

STATIONS.	High Tide, Philad'a.	Ocean Level.	
Columbia § Table I.	241.3	251.3	
Wrightsville	247.5	257.5	
Creitz Creek ‖	263.	273.	
Hellam	336	346	
Heistand's	327.2	337.2	
York (N. Central R. R.) Tab.	371.7	381.7	

* Junction with Pennsylvania R. R. at Pomeroy Station, 43 (42.2?) miles west of Philadelphia.

** Crossing the Philadelphia and Baltimore Central R. R.

† Crossing of the Delaware Railway Line.

‡ Crossing of the Philadelphia, Wilmington and Baltimore R. R.

§ Junction with the Columbia Branch of the Pa. R. R.

‖ Bench mark on east end of coping girder of bridge No. 3, over road and Creitz Creek.

V. Mifflin and Centre Co. R. R.

The levels of the Mifflin and Centre Co. Railroad were copied from a profile in the office of the Pennsylvania R. R. Co., at Philadelphia, furnished by Mr. W. H. Wilson, Consulting Engineer, Pennsylvania R. R.

The datum is that of the Pennsylvania R. R., 7 *feet added*, to reduce to mean Atlantic level, in the second column.

STATIONS.	Above Tide.	Ocean Level.
Lewistown Junction*.....	492	499
Logan.....	527	534
Yeagertown.....	561	568
Mann's.....	673	680
Reedsville.....	695	702
Honey Creek.....	807	814
Nagney.....	849	856
Milroy†.....	987	994

VI. Sunbury and Lewistown R. R.

NOTE.—No records of this road could be obtained.

VII. East Broad Top Narrow Gauge R. R.

The levels on the East Broad Top R. R. (3 foot gauge), were copied from a profile in the office of the Company, at Orbisonia, by permission of Mr. A. W. Sims, Superintendent.

The datum of the profile is an assumed elevation, and has been reduced to tide level by reference to the Pennsylvania R. R. grade at Mount Union, 590′, with 7′ added to reduce to mean Atlantic Ocean level.

STATIONS.	Assumed Datum.	Ocean Level.
Mount Union Junction ‡.....	810.65	597
Morrison's Summit.....	828	615
Aughwick Creek.....	773.60	560
Shirleysburg.....	784.94	572
Douglas Summit.....	811.24	598
McMullen's Summit.....	882.74	669
Orbisonia.....	837.62	624
Jordan's Summit.....	922.22	709
Scottsville.....	929.85	717
Saltillo.....	994.70	781
Moreland's Summit.....	1326.90	1114
Sidling Hill.....	1445.47	1232
Cole's Station.....	1572.06	1359
Cook's Mill.....	1741.28	1528
Cook's Station.....	1754.24	1541
Coal Openings.....	1978.10	1765
Robertsdale.....	1998.70	1785
End of Road §.....	2030.02	1817

* With the Pennsylvania R. R. near the Lewistown Station. Table I.

† Terminus in the Kishicoquillis Valley. This survey has been extended through the Seven Mountains to Bellefonte.

‡ East Broad Top R. R. connects with Pennsylvania R. R. at Mount Union.

§ On the plateau of the Broad Top Mountain in Huntingdon County.

VIII. Huntingdon and Broad Top R. R.

The levels on the Huntingdon and Broad Top R. R. and its Branches, were furnished by Mr. John Fulton, General Mining Engineer of the Cambria Iron Works at Johnstown, Pa.

The datum is 0 at grade on the Pennsylvania R. R. at Huntingdon. To this 614′ are added, +7′, to reduce all to mean Atlantic Ocean level.

This road has three coal branches up the three streams which drain the Broad Top Coal Region. It originally stopped at Everett; but has been continued to Bedford and Bridgeport under the name of the Bedford and Bridgeport Railroad. Table IX.

The elevations on the Bedford and Bridgeport R. R. were furnished by Mr. S. M. Prevost, Superintendent of the Bedford Division of the Pennsylvania R. R.

The datum 0 of this road was at grade of the Pennsylvania R. R at Huntingdon; which Mr Prevost called 610; while Mr. Wilson calls it 614. The difference of 4 feet has therefore, in the 2d column, been added to Mr. Prevost's figures, to make them agree with Mr. Wilson's figures, along the main line. The regular 7 feet addition has also been made in the second column to reduce to mean Atlantic Ocean level.

STATIONS.	Above Huntingdon.	Ocean Level.
Huntingdon	000	621
McConnellstown	56.2	677
Pleasant Grove	127.2	748
Marklesburg	167.6	789
Coffee Run	250.6	872
Rough and Ready	267.6	889
Cove	300	921
Fisher's Summit	253	874
New Bridge	210.3	831
Saxton (new depot)	228	849
Riddlesburg	243.6	865
Hopewell	277.3	898
Piper's Run	326.3	947
Brallier's Summit	487.3	1108
Tatesville	475.3	1096
Bloody Run Summit	613.3	1234
Everett	497 3	1118

IX. Continued as the Bedford and Bridgeport R. R.

Mount Dallas (above tide)	1046	1053
Cove Creek	1026	1033
Lutzville	1038	1045
Bedford	1055	1062
Wolfsburg Summit	1111	1118
Napier	1101	1108
Mann's Choice	1129	1136
Buffalo Summit	1349	1356
Fossilville	1084	1091
Bridgeport (*a*)	923	930
Maryland State Line (*b*)	837	840

(*a*) Not the Bridgeport of Clearfield County in Table XIV.

(*b*) Continued as Baltimore, Connellsville & Pittsburgh R. R. Branch of the Baltimore and Ohio R. R.

X. Shoup's Run Branch of H. & B. T. R. R.

Saxton (as above)	228	849
Coalmont	488.8	1110
Crawford	620.9	1242
Old M. P	662 7	1284
No. 3. Mine	784.5	1405
Barnet Mine	767	1388
Dudley Station	803.6	1425
Blair's Mine	815.2	1436
Moredale	1058.7	1680
Water Station	1088	1709
End of Track	1240.2	1861

XI. Six Mile Run Branch of H. & B. T. R. R.

Riddlesburg (as above)	243.6	865
" Coal Mine	340.9	962
Coaldale	505.2	1126
End of 3d Mile	573	1194
End of 4th Mile	753	1374
End of Track	795	1416

XII. Sandy Run Branch of H. & B. T. R. R.

Hopewell (as above)	277.3	898
End of Track	404	1025

XIII. Lewisburg, Centre and Spruce Creek R. R.

NOTE.—The levels on the Lewisburg Centre and Spruce Creek R. R. were furnished by Mr. George W. Leuffer, Chief Engineer. Mr. Leuffer says, "I will remark that many of the Stations have, as yet, not been located. The tide levels are based upon a level furnished by A. B. Starr, Esq., Engineer of P. & E. R. R., of a point in abutment of Chilesquaque Bridge (of P. & E. R. R.), and this agrees so closely with the level of tide, as stated in printed table of Pennsylvania R. R. Co., of Tyrone City, that I am inclined to rely upon the levels I now enclose."

The first column, then, gives the figures of Mr. Leuffer.

The second column has 7 feet added to Mr. Leuffer's figures, on the supposition that his datum is Pennsylvania R. R. datum of high water at the Schuylkill Bridge.

The third column has 8 feet added (in addition, = 15 feet in all) to agree with the final mean Atlantic Ocean level assigned to Tyrone, in the Pennsylvania R. R. list, No. I.

STATIONS.	Above Tide.*	Ocean Level.†	Ocean Level.‡
P. & E. R.R. Junction(*a*)	447	454	462
Lewisburg	451	458	466
Biehl	503	510	518
Vicksburg	514	521	529
Mifflinburg	550	557	565
Millmont	570	577	585
Laurelton	592	599	607
Tunnel (*b*)	944	951	959
Fowler's	976	983	991
Beaver Dam Tunnel	999	1006	1014
Caburn (*c*)	1011	1018	1026
Buchannon (*d*)	1044	1051	1059
Duncan	1063	1070	1078
Centre Hall	1257	1264	1272
Summit (*e*)	1275	1282	1290
Lemont (*f*)	987	994	1002
Kelly (*g*)	1096	1103	1111
Pinegrove	1221	1228	1236
Shugarts	1116	1123	1131
Lyon (Penna. Furnace).	1059	1066	1074
Guyer (*h*)	1129	1136	1144
Lowrie (*i*)	1094	1101	1109
Miller (*j*)	1055	1062	1070
Tyrone (*k*) (I)	892	899	907

XIV. Tyrone and Clearfield R. R.

The elevations on the Tyrone and Clearfield R. R. were copied from a profile in the office of the Pennsylvania R. R. Co. in Philadelphia. The datum is a point 60′ below Tyrone, or as it appears on the profile elevation at Tyrone + 840′. Mr. W. H. Wilson is authority for adding 60′ to each elevation as shown on the profile.

In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

* High tide, Schuylkill River, at Philadelphia?

† Calculated from the Lewisburg end.

‡ Adjusted to the Pennsylvania R. R. record at the Tyrone end.

(*a*) Junction with Philadelphia and Erie R. R

(*b*) Through Paddy's Mountain.

(*c*) Forks of Penn's Creek.

(*d*) Mouth of Muddy Run.

(*e*) Summit of Penn's Valley, Head of Penn's Creek, and Head of Spring Creek, which enters Bald Eagle Creek after passing Bellefonte.

(*f*) End of Nittany Mountain.

(*g*) State Agricultural College.

(*h*) Half Moon Gap.

(*i*) At Warrior's Mark.

(*j*) Logan's Run.

(*k*) L. C. & Sp. Cr. R. R. here connects with the Pennsylvania R. R.

STATIONS.	Above Tide.	Ocean Level.
Tyrone (Pennsylvania R. R.)..(I)	900	907
Bald Eagle R. R. Junction	977	984
Vanscoyoc	1410	1417
Gardners	1561	1568
Mt. Pleasant	1767	1774
Emigh's Summit (*a*)	2033	2040
Sandy Ridge	1915	1922
Powelton	1791	1798
Osceola Branch R. R.	1481	1488
Dunbar	1446	1453
Moshannon Creek	1443	1450
Steiner's Mill	1421	1428
Philipsburg	1415	1422
Blue Ball	1513	1520
Shimmels	1634	1641
Wallacetown	1675	1682
Turner's Summit	1735	1742
Moravian Run	1731	1738
Ross' Summit	1744	1751
Smael's Summit	1709	1716
Camp Hummel	1743	1750
Bigler	1655	1662
Woodland	1465	1472
Roaring Run	1420	1427
Leonard's Point	1299	1306
Clearfield Creek	1133	1140
Sharon's Run	1105	1112
Liberty Spring	1096	1103
Clearfield	1096	1103
Goodfellow's Bridge	1103	1110
Spackman's Bluff	1110	1117
Susquehanna River	1117	1124
Hog Back	1119	1126
Hartshorn's Run	1125	1132
Curwensville	1134	1141
Anderson's Creek (*b*)	1144	1151
Anderson's Creek (*c*)	1159	1166
Bridgeport (*d*)	1183	1190

XV. Bald Eagle Valley R. R.

The elevations on the Bald Eagle Valley R. R. were copied from a profile in the office of the Pennsylvania R R. Company, at Philadelphia. The datum is the same as that of the P. R. R.

In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

(*a*) Allegheny Mountain Summit.
(*b*) First Crossing.
(*c*) Second Crossing.
(*d*) Not the Bridgeport of Bedford County in Table IX.

STATIONS.	Above Tide.	Ocean Level.
Tyrone (as above)	900	907
Spring Run	888	895
Dallas Street	921	928
Sinking Run	923	930
Little B. E. Creek	940	947
Bald Eagle	1051	1058
L. B. E. Bridge	1065	1072
Summit	1103	1110
Hannah	1050	1057
Port Matilda (*a*)	1000	1007
B. E. Creek Bridge	917	924
Martha	905	912
Julian	844	851
Dick's Run	794	801
Unionville	775	782
Snow Shoe R. R.....(XVI)	715	722
Milesburg.....(XVII)	693	700
Bald Eagle Canal	664	671
Holters'	644	651
Mount Eagle	655	662
Bald Eagle Plank Road	658	665
Howard	672	679
Eagleville	628	635
Beach Creek	607	614
Mill Hall	566	573
Lock Haven Junction (*b*)	548	555

(*a*) Main Street.
(*b*) Junction with the Philadelphia and Erie R. R.

XVI. Bellefonte and Snow Shoe R. R.

The levels on the Bellefonte and Snow Shoe R. R. were furnished by Mr. I. L. Sommerville, Resident Engineer. The datum is that of the Pennsylvania R. R.

In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.
Bellefonte.....(XVII)	737	744
Bald Eagle R. R. Junction..(XV)	715	722
Gum Stump	1013	1020
Summit (*a*)	1728	1735
Beach Creek (*b*)	1542	1549
Beach Creek (*c*)	1592	1599
Snow Shoe	1565	1572
Middle Coal bed (*d*)	1599	1606

(*a*) Allegheny Mountain summit.
(*b*) *Level of water* in Beach Creek.
(*c*) Level of rail over the water.
(*d*) Middle coal bed at the Company's mines at Coal Hill.

XVII. Bellefonte Branch.

The levels on the Bellefonte Branch were copied from a profile in the office of the Pennsylvania R. R. Company, at Philadelphia, and have the datum of the P. R. R. to which are added seven feet to reduce to mean Atlantic Ocean Level, in the second column.

STATIONS.	Above Tide.	Ocean Level.	
Milesburg (*a*).....(XV)	693	700	
B. E. V. Plank Road.....	692	699	
Bellefonte.....(XVI)	737	744	

XVIII. Bell's Gap (N. G.) R. R.

The elevations on the Bell's Gap Narrow Gauge R. R. (3 fect) were furnished by Mr. Jos. Ramsey, Jr., Superintendent.

The datum for the first column is 0 at Pennsylvania R. R. grade at Bell's Mills Station. To which are added 1053′ from Table I for the second column, and 7′ for the third column, to reduce to mean Atlantic Ocean Level.

STATIONS.	Bell's Mills.†	Corrected Tide.	Ocean Level.	
Bell's Mills Junction (I).	0	1053	1060	
Roots'.....	162	1215	1222	
Collier.....	581.6	1635	1642	
Point Lookout.....	854.6	1908	1915	
Lloyd's Junction (*a*)...	1107.4	2160	2167	
Lloyd's Station.....	1119.7	2173	2180	
Summit (*b*).....	1240.5	2294	2301	
Five Foot Coal (*c*).....	——	2116	2123	
Figart's.....	1048	2101	2108	
Vanscoyoc.....	935	1988	1995	
Crees Summit.....	797	1850	1857	
Hollen's (*d*).....	582	1635	1642	
Three Foot Coal.....	——	1667	1674	
Five Foot Coal.....	——	1727	1734	
Van Ormer's (*e*).....	352.3	1405	1412	
Three Foot Coal.....	——	1475	1482	
Fallen Timber.....	362.	1415	1422	

(*a*) Junction with the Bald Eagle Valley R. R.

(*a*) Elevation of 5 foot coal bed at the mouth of gangway.

(*b*) Allegheny Mountain. Bench Mark, Summit of Mountain.

(*c*) Level of the 5 foot coal bed under the Bench Mark.

(*d*) Elevation at this point of the 3′ vein, 1667′; of the 5′ vein, 1727′.

(*e*) Elevation of *Water in Clearfield Creek*. The elevation of the 3′ vein here is 1475.

XIX. Hollidaysburg Branch P. R. R.

The levels on the Hollidaysburg Branch of the Pennsylvania R.R. were copied from a profile in the office of the P. R. R. Company, at Philadelphia.

The datum being mean high tide at the Schuylkill Bridge, seven feet are added in the second column to reduce the mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.
Altoona (Pennsylvania R. R.)..(I)	1172	1179
Allegheny	1145	1152
Eldorado	1086	1093
Canon's	1059	1066
Duncansville	983	990
Hollidaysburg.....(XX)	946	953
End of Line (*a*)	937	944

(*a*) 3400′ beyond the station marked Hollidaysburg.

XX. Williamsburg Branch P. R. R.

The levels on the Williamsburg Branch, the Morrison's Cove Branch, the Bloomfield Branch, and the Springfield Branch of the Pennsylvania R. R., were copied from profiles in the office of the Pennsylvania R. R. Company, at Philadelphia.

The datum being mean high tide at the Schuylkill Bridge, seven feet are added to reduce to mean Atlantic Ocean Level.

The Williamsburg Branch R. R. has been substituted for the old State Canal, long since vacated, from Frankstown to Williamsburg, and shows the fall of the Juniata River.

STATIONS.	Above Tide.	Ocean Level.
Graysport (*a*)	947	954
Hollidaysburg.....(XIX)	935	942
Brush Run	1026	1033
Juniata River (*b*)	911	918
Reese Station	896	903
Clapper's Run	894	901
Koofer's Run	886	893
Juniata River (*c*)	886	893
Pike Ponds	878	885
Flowing Spring	874	881
Springfield R.R. Junc. (*d*) (XXIII)	874	881
Williamsburg	840	847

(*a*) Bench Mark on step of ladies' waiting room, Graysport passenger station, 946.60.

(*b*) Frankstown or Main Branch of the Juniata River.

(*c*) Frankstown or Main Branch of the Juniata River.

(*d*) Springfield Branch.

XXI. Morrison's Cove Branch P. R. R.

STATIONS.	Above Tide.	Ocean Level.
Hollidaysburg .....(XIX)	936	943
Draw Bridge	935	942
Juniata River (*e*)	935	942
Reservoir	960	967
Catfish	961	968
Riddle's Lane	966	973
Brooks Mill	999	1006
McKee's Gap (*f*)	1029	1036
Martha Furnace	1047	1054
Hammond's	1126	1133
Roaring Spring Junction.. (XXII)	1199	1206
Erb's Summit	1347	1354
Martinsburg Junction	1337	1344
Martinsburg.....	1359	1366
Henrietta Junction.....	1384	1391
Mathew's Summit	1465	1472
Nicodemus' Summit	1425	1432
Clover Creek	1385	1392
Henrietta Ore Bank	1402	1409
End of Road (*g*).....	1415	1422

XXII. Bloomfield Branch P. R. R.

STATIONS.	Above Tide.	Ocean Level.
Roaring Spring (*h*).....(XXI)	1196	1203
Trestle, No. 1	1214	1221
Trestle, No. 2.....	1351	1358
Bloomfield (*i*)	1453	1460

XXIII. Springfield Branch P. R. R.

STATIONS.	Above Tide.	Ocean Level.
Williamsburg R. R. Junc....(XX)	874	881
Trestle, No. 1.....	961	968
Goods.....	999	1006
Davis Summit	1372	1379
8th Mile Post (*j*).....	1367	1374

(*e*) Frankstown Branch of the Juniata River.

(*f*) Through Dunning's Mountain.

(*g*) In Leather Cracker Cove, the southern end of Morrison's Cove.

(*h*) Junction of this branch with Morrison's Cove Branch R. R. XXI.

(*i*) Iron Mines and Furnaces.

(*j*) This R. R. ascends from the Juniata River to the Springfield Ore Mines in Canoe Valley, the northeast prolongation of Morrison's Cove.

XXIV. Ebensburg and Cresson R. R.

The elevations on the Ebensburg and Cresson Railroad were copied from a profile in the office of the Pennsylvania R. R. Company, in Philadelphia.

The datum is mean high water at the Schuylkill Bridge, to which are added seven feet to reduce to mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.
Cresson R. R. Junction (*a*)....(I)	2021	2028
Plank Road Crossing	2032	2039
Lilly	2023	2030
O'Harra	2008	2015
Durbin	1920	1927
Sander's	2012	2019
Bradley's	2111	2118
Dam (*b*)	1953	1960

(*a*) The Junction with Pa. R. R. is not *at* Cresson 2010′ (2017′) but *near* Cresson 2021′ (2028).

(*b*) This is the last point on the profile where the elevation is given.

XXV. Blairsville and Indiana Branch P. R. R.

The elevations on the Blairsville and Indiana Branch of the Pennsylvania R. R. were taken from a profile in the office of the P. R. R. Company, at Philadelphia.

The datum is high tide Schuylkill River, at the Philadelphia Market Street Bridge. To this seven feet are added in the second column to reduce to mean Atlantic Ocean Level.

STATIONS.	Above Tide.	Ocean Level.
R. R. Junction (*a*).....(I)	1104	1111
Pennsylvania Canal	958	965
R. R. Junction (*b*)	970	977
Blairsville (*c*)	1004	1011
Smith's Summit	1096	1103
Wier's Run	963	970
Black Lick	956	963
Water Station	959	966
Black Lick Bridge	1075	1082
Doty's Bridge	1004	1011
Rough's	1021	1028
Saw Mill Run	1009	1016
Bell's Mill's Run	1025	1032
Phillips' Summit	1037	1044
Kissinger's Summit	1048	1055
Two Lick Creek	1037	1044
Reed's	1138	1145
Indiana Terminus	1304	1311

(*a*) With the Main line Pennsylvania R. R. on the side of Chestnut Ridge, high above the bed of the river.

(*b*) With the Indiana and Blairsville Branch

(*c*) Market Street Station, in Blairsville.

XXVI. West Penn R. R.

The levels of the West Penn R. R. were copied from a profile in the office of the Pennsylvania R. R. Company, at Philadelphia.

The datum is mean high tide in the Schuylkill River, at Philadelphia. In the second column seven feet are added to reduce to mean Atlantic Ocean Level.

This Railroad follows down the valley of the Kishkiminitas from Blairsville to Freeport, sometimes using the bed of the old State Canal.

STATIONS.	Above Tide.	Ocean Level.	
Blairsville (*a*).....XXV	1004	1011	
Livermore.....	938	945	
Saltzburg (*b*)	884	891	
Fairbank's (*c*).....XXVII	926	933	
Helma	1010	1017	
Salina.....	948	955	
North West.....	887	894	
Roaring Run	823	830	
Apollo	816	823	
Townsend's Summit	880	887	
Grinder's	820	827	
Hill's Mill.....	773	780	
A. V. R. R. Crossing (*d*).....	778	785	
Freeport (*e*).....XXVIII	763	770	
Sligo.....	768	775	
Karn's	761	768	
Natrona.....	761	768	
Tarentum	750	757	
Bailey's Run	746	753	
Springdale	742	749	
Harmersville	736	743	
Fairview	734	741	
Ross	738	745	
Sharpsburg (*f*)	732	739	
Bennett's.....	734	741	
Duquesne Borough.....	734	741	
Allegheny City (*g*).....	736	743	
Allegheny City (*h*)	738	745	
Allegheny City (*i*).....	736	743	
Terminus (*j*)	734	741	

(*a*) Market Street Station, Blairsville.

(*b*) Market Street, Saltzburg.

(*c*) Coal R. R. here connects, see next table XXVII.

(*d*) Crossing Allegheny Valley R. R.

(*e*) Second Street, Freeport.

(*f*) Main Street, Sharpsburg.

(*g*) Sycamore Street, Allegheny City.

(*h*) Chestnut Street, Allegheny City.

(*i*) East Lane, Allegheny City.

(*j*) Opposite Pittsburgh and connecting with the Pittsburgh, Fort Wayne and Chicago R. R. lines.

XXVII. Branch of W. P. R. R.

The levels on the Branch of the West Penn Railroad from Fairbank's Station to the Coal Mines were furnished by Mr. George W. Leuffer, C. E. The datum 0 is at grade of W. P. R. R., Fairbank's Station.

STATIONS.	Above Tide.	Ocean Level.
Fairbank's Junction.....XXVI	926	933
Grade near Mines.....	1111	1118
Bottom of Coal Bed.....	1133	1140

XXVIII. Butler Branch W. P. R. R.

The levels on the Butler Branch Extension of the West Penn R. R. were furnished by Mr. Antes Snyder, Engineer, Springdale, Allegheny County, Pa.

There is an unexplained difference of 29.5 *feet* between the Butler Branch R. R. grade and the West Penn R. R. grade at Freeport, where they ought to be the same.

Another list was obtained from Mr. J. M. C. Creighton, differing very slightly from Mr. Snyder's; but still leaving *an unexplained difference of* 27 *feet at Freeport.*

The second column in the first table gives Mr. Snyder's levels *let down* 29½ *feet*, and in the second table Mr. Creighton's levels let down 27 feet.

The third column has seven feet added to reduce to mean Atlantic Ocean Level.

The datum of both tables is called "Mid Tide" at Philadelphia, which would require an addition of only 3.349 feet (instead of 7) to his original figures. See foot note on page 64. But this "Mid-Tide" may be a mistake for the "Mean High Tide" of the Pennsylvania R. R. Company's datum and is so taken.

STATIONS.	Mid Tide Philada.	2d Column.	Ocean Level.
Freeport Junc....XXVI	792.5†	763‡	770
Buffalo.....	792.5	763	770
Monroe.....	865.5	836	843
Sarver's.....	1056	1026.5	1034.5
Saxon.....	1254.5	1225	1232
Delano.....	1255.5	1226	1233
Dilke's.....	1335	1305.5	1313.5
Summit ‖.....	1344.5	1315	1322
Great Belt City.....	1286.5	1257	1264
Summit §.....	1328	1298.5	1306.5
Herman.....	1323.5	1394	1301
Bunker's.....	1285.5	1256	1263
Butler.....A	1031.5	1002	1009

† Levels furnished by Mr. Antes Snyder.

‡ Elevation on profile of West Penn R. R. at Freeport.

‖ West of Dilke's.

§ East of Herman.

STATIONS.	Mid Tide Philada.	2d Column.	Ocean Level.
Freeport Junc....XXVI	790†	763‡	770
Buffalo	788	761	768
Harbison	824	797	804
Monroe	862	835	842
Sarver's	1052	1025	1032
Saxonberg	1227	1200	1207
Delano	1252	1225	1232
Dilke's	1337	1310	1317
Great Belt	1285	1258	1265
Herman	1318.50	1291	1298
Bunker	1288.38	1261	1268
Butler.....B	1030	1003	1010

XXIX. Ligonier Valley R. R

The levels on the Ligonier Valley R. R. were copied from notes in possession of Mr. George L. Miller, C. E., Pittsburgh, Pa. The datum is Pennsylvania R. R. at Latrobe. To which add 1144 for high tide at Philadelphia.

STATIONS.	Above Tide.	Ocean Level.
Ligonier	1144	1151
Mill Creek.....(Surface of water)	1131	1138
Coal Pit Run	1132	1139
Schriner's Run	1127	1134
Turnpike Crossing (*a*)	1123	1130
Butler Milk Falls (*b*)	1123	1130
Baker's Saw Mills (*c*)	1117	1124
Little Rock Hollow	1096	1103
Big Rock Hollow	1080	1107
Kellog's Hollow	1068	1075
Iron Ore (*d*)	1040	1047
Johnson's Forge	1036	1043
Derry Road Crossing	1030	1037
Mitchell's Run (*e*)	1029	1036

XXX. S. W. Pennsylvania R. R.

The levels of the South West Pennsylvania R. R. were furnished by Mr. G. W. Leuffer, Engineer.

The datum or base of levels is ordinary High Tide at Philadelphia.

† Elevations furnished by Mr. J. M. C. Creighton, Superintendent, West Penn. Division, Pennsylvania R. R.

‡ Elevation on profile of West Penn R. R. at Freeport.

(*a*) Greensburg and Stoystown.

(*b*) Loyalhanna Creek.

(*c*) At a point opposite Baker's Saw Mills.

(*d*) Out-crop of iron ore on line of R. R. 7 miles from Ligonier and 3 miles from Latrobe.

(*e*) Near Latrobe on the Pennsylvania R. R. Table I.

STATIONS.	Above Tide.	Ocean Level.
Greensburg Junction (*a*).....I	1093	1100
East Greensburg.....	1055	1062
Huff's.....	994	1001
County Home.....	972	979
Fosterville.....	960	967
Youngwood.....	950	957
Jack's Run.....	947	954
Paintersville.....	945	952
Sewickley Creek.....	936	943
Hunker's.....	938	945
Bethany.....	1044	1051
Tarr's.....	1092	1099
Stoner's Summit.....	1138	1145
Hawk Eye.....	1060	1067
Scottdale.....	1035	1042
Jacob's Creek.....	1027	1034
Everson.....	1027	1034
Valley Works.....	1068	1075
Pennsville Summit.....	1086	1093
Pennsville.....	1047	1054
Davidson.....	891	898
Connellsville.....	908	915

(*a*) Junction with Pennsylvania R. R. near Greensburg.

XXXI. Yohiogheny R. R.

The elevations on the Yohiogheny R. R. were copied from notes in the possession of Mr. John F. Wolf, Engineer Pennsylvania Gas Coal Co., Irwin's Station, Westmoreland County, Pa.

The datum is Pennsylvania R. R. at:

STATIONS.	Above Tide.	Ocean Level.
Irwin's Stat. P. R. R. (*a*).....I	877	884
Shaft No. 2.....	986	993
Tunnel.....	1104	1111
Chamber's.....	1075	1082
McGrew's.....	974	981
Millgrove.....	926	933
Little Sewickley (*b*).....	797	804
Marchand's (*c*).....	763	770
Yohiogheny (*d*).....	776	783
Sewickley Station (*e*).....	773	780
R. R. Junction (*f*).....	761	768

(*a*) Junction with Pennsylvania R. R. at Irwin's Station.
(*b*) First Crossing Little Sewickley Creek.
(*c*) Yohiogheny Mine, No. 1, Shaft No. 3, elevation of Coal, 720'.4 above Tide.
(*d*) Yohiogheny Mine, No. 2, elevation of Coal 776'.4 above Tide.
(*e*) Mine No. 4, elevation of Coal opening at this point 800'.4 above Tide.
(*f*) Junction with Pittsburgh and Connellsville R. R.

II. READING SERIES.

L. Philadelphia and Reading R. R.

The elevations at the following points on the Philadelphia and Reading Railroad and Branches, were furnished by Mr. Wm. Lorenz, Chief Engineer.

The number of stations given in the tables, are few, but no others could be obtained.

The datum is *mid tide* at Philadelphia.

To this must be added 3.349 feet to reduce to Atlantic Ocean Level.

STATIONS.	Mean Tide.	Ocean Level.	
Philadelphia (*a*)			
Nicetown Summit (*b*)..,.....LI	111	114	
Belmont.....			
West Falls.....			
Pencoyd			
West Manayunk.....			
Mill Creek.....			
West Spring Mill			
West Conshohocken.....			
Swede Furnace			
Bridgeport (*c*).....LII			
Merion.....			
Port Kennedy (*c*).....LII			
Valley Forge			
Perkiomen Junction (*d*).....LIV			
Phœnixville (*e*).....LIII	105	108	
Mingo.....			
Royer's Ford.....			
Limerick			
Pottstown (*f*).....LV	146	149	
Douglassville			
Monocacy			
Birdsboro (*g*).....	170	173	
Exeter			
Neversink.....			
Reading (*h*)...LVI, LVII, LVIII, LIX.....	264	267	
Tuckerton.....			
Leesport.....	292	297	
Mohrsville			
Shoemakersville			
Hamburg.....	361	364	
Port Clinton (*i*).....LXII	397	400	
Auburn (*j*).....LXIII	457	460	
Landingville.....			
Schuylkill Haven (*k*).....( )	520	523	
Mount Carbon.....	591	594	
Pottsville (*l*) LXVI	603	606	

a Richmond Street Bridge, near the Coal Depots on the Delaware River.

b In Philadelphia, near the Germantown Road. The Germantown R. R.

LI. Germantown and Norristown Branch P. & R. R. R.

STATIONS.		Mean Tide.	Ocean Level.
Philadelphia (*a*)	I	39	42
Nicetown (*b*)		132	135
Columbia Avenue	See below		
New York Junction			
Tioga			
Wayne			
Fisher's			
Duey's (or Wistar Street)			
Shoemaker's			
Church Lane			
Germantown Depot (*m*)		212	215
Chestnut Hill		404	407
Philadelphia			
Columbia Avenue	See above	39	42
New York Junction			
East Falls			
School Lane			
Wissahickon			
Schur's			
Manayunk			
Springfield			
Shawmont			
Princeton			
Lafayette			
Spring Mill			
Conshohocken			
Potts Landing			
Magee's			
Norristown (*n*)	CIII	62	65

crosses the P. & R. R. R. in Nicetown on a bridge at an elevation of 132 (135). feet; but not at this summit. Table LI.

c Norristown opposite Bridgeport is given in this list as 62 (65.) See Table LI. Bridgeport is at the Junction of the Chester Valley R. R. See Table LII. R. R. to King of Prussia; no levels furnished.

d Perkiomen R. R.

e Pickering Valley R. R.

f Colebrookdale R. R.

g Wilmington and Reading R. R.

h Lebanon Valley R. R. Reading and Columbia R. R. East Penn R. R.

i Little Schuylkill R. R.

j Schuylkill and Susquehanna R. R.

k West Branch R. R.

l Mill Creek R. R. Schuylkill Valley R. R.

a Depot at the corner of 9th and Green Streets.

b Crosses the P. & R. R. R. on a bridge, but not at the Nicetown Summit mentioned in Table L.

m Probably the old Depot.

n The N. Penn. R. R. level, Stony Creek branch, is 50 (62 Ocean level).

LII. Chester Valley Railroad

The levels on the Chester Valley Railroad, were furnished by Mr. W. H. Holstein, Secretary of the Chester Valley Railroad Company.

The road connects with the Philadelphia and Reading Railroad at Bridgeport, and with the Pennsylvania R. R. at Downingtown.

The base of the levels is *mid tide* at Philadelphia. Add 3.349 to reduce to Ocean level.

STATIONS.	Mean Tide.	Ocean Level.	
Bridgeport (*a*).....L	73	76	
Shainlines.....	133	136	
Henderson's.....	162	165	
King of Prussia.....	187	190	
Centreville	199	202	
Gardens.....	222	225	
Howellville.....	218	221	
Paoli Road.....	235	238	
Cedar Hollow.....	243	246	
Lee's.....	276	279	
Valley Store.....	292	295	
Mill Lane	312	315	
White Horse.....	336	339	
Exton.....	321	324	
Oakland.....	298	301	
Baldwin's.....	296	299	
Downingtown (*b*).....I	264	267	

LIII. Pickering Valley R. R.

Of this line only one level was furnished.

Datum (Reading R. R.) mean tide at Philadelphia. Add 3.349 for Ocean level.

STATIONS.	Mean Tide.	Ocean Level.	
Phœnixville L	(105)	(108)	
French Creek.....			
Kimberton			
Pikeland			
Chester Springs			
Cambria.....			
Byer's Eagle Summit.....	450	453	

a Opposite Norristown, Table L.

b On the Pennsylvania R. R.

LIV. Perkiomen R. R.

STATIONS.	Mean Tide.	
Perkiomen Junction (*a*).....L		
Oaks.....		
Doe Run.....		
Yerke's.....		
Collegeville.....	151	154
Rahn's.....		
Grater's Ford.....		
Skippack.....		
Schwenksville.....	149	152
Green Land.....	245	248
Emaus Junction (*b*).....LXI		

a Reading R. R.
b East Penn R. R.

LV. Colebrookdale R. R.

STATIONS.	Mean Tide.	Ocean Level.
Pottstown (*a*).....L	(146)	(149)
Glasgow.....		
Manatawny.....		
Iron Stone.....		
Colebrookdale.....		
Boyertown.....	388	391
New Berlin.....		
Bechtelsville.....		
Mt. Pleasant.....	466	469
Rittenhouse Gap.....		
Alburtis (*b*).....LXI	(427)	(430)

a Reading R. R.
b East Penn R. R.

LVI. Wilmington and Reading R. R.

STATIONS.	Mean Tide.	Ocean Level.
Reading.....L	(264)	(267)
Birdsboro (*a*).....L	(170)	(173)
Springfield.....		
Coatesville (*b*).....I		
Chadd's Ford (*c*).....		
Wilmington (*d*).....		

a Junction with Philadelphia and Reading R. R.
b Crosses Pennsylvania R. R.
c Crosses Philadelphia and Baltimore R. R.
d Connects with Philadelphia, Wilmington and Baltimore R. R.

LVI. Wilmington and Reading R. R.

These levels of the Wilmington and Reading R. R. were furnished by Mr. E. Collings, Superintendent.

The datum, or base of levels, is low tide at Wilmington, Del. Relation of Ocean Level to this datum is unknown.

STATIONS.	Low Tide.	Ocean Level.	
Birdsboro Junction (*a*).....L	173	(173)	
Hampton.....	223		
White Bear.....	349		
Geigertown.....	432		
Cold Run.....	525		
Joanna.....	627		
Springfield.....	645		
Conestoga.....	647		
Isabella.....	639		
E. B. & W. R. R. Crossing (*b*)..II	647		
Beaver.....	603		
Honeybrook.....	596		
Manor.....	572		
Hibernia.....	530		
Brandywine.....	556		
Coatesville (*c*).....I	315		
Modena.....	278		
Mortonville.....	260		
Laurel.....	241		
Embréiville.....	231		
Glen Hall.....	218		
Northbrook.....	209		
Seeds.....	195		
Lenape.....	183		
Pecopson.....	180		
Chadd's Ford.....	175		
Smith Bridge.....	209		
Centre.....	263		
Dupont's.....	282		
Wilmington.....	12	(12)	

a Junction with Philadelphia and Reading R. R. at Birdsboro, Berks County, Pennsylvania.

b Junction with E. Brandywine and Waynesburg R. R., Chester County, Pa.

c The Pennsylvania R. R. track on bridge just west of Coatesville Station is 62′ higher than track on W. & R. R. R. The elevation on Pennsylvania R. R. at the point where it crosses the W. & R. R. R. is 374′ above tide. By deducting 62′ according to Pennsylvania R. R. datum the elevation would be 312′. The datum of the Pennsylvania R. R. is high tide in Schuylkill River. The datum of W. & R. R. R. is low tide at Wilmington.

LVII. Lebanon Valley R. R.

STATIONS.	Mean Tide.	Ocean Level.
Reading (*a*).....L	(264)	(267)
Schuylkill Bridge.....	262	265
Sinking Springs (*b*).....LVIII	(341)	(344)
Wernersville.....	376	379
Heidelburg.....	376	379
Robesonia.....	428	431
Sand Holes Summit.....	450	453
Womelsdorf.....	433	436
Smiths'.....	425	428
Missimer's.....	425	428
Richland.....	420	423
Myerstown.....	460	463
Prescott.....	503	506
Avon.....	467	470
Lebanon.....	456	459
C. R. R. Junction (*c*).....LX	444	447
L. & T. R. R. Junction (*d*)...LIX	439	442
Annville.....	436	439
Palmyra.....	443	446
Spring Creek.....	384	387
Hummelstown.....	360	363
Swatara Creek.....	355	358
Swatara Hills Summit.....	428	431
Rutherford's.....	425	428
Paxton.....	363	366
Harrisburg (*e*).....I	308	311

a Reading R. R.
b Reading and Columbia R. R.
c Cornwall R. R. Junction.
d Lebanon and Tremont R. R. Junction.
e West Line of Lebanon Valley Depot, Harrisburg, which, however, according to Pennsylvania R. R. Table I, is 315.5; probably more correct than 308.

LVIII. Reading and Columbia R. R.

STATIONS.	Above Tide.	Ocean Level.
Reading.....L	(264)	(267)
Sinking Springs (*a*).....LVII	341	344
Deep Cut (*b*).....	566	569
Fitztown.....		
Reinhold's.....		
Union.....		
Ephrata.....	378	381

a Junction with the Lebanon Valley Road.
b South Mountain Summit.

LVIII. Reading and Columbia R. R.—CONTINUED.

STATIONS.	Above Tide.	Ocean Level.	
Rothville Summit (*c*)	401	404	
Litiz			
Manheim			
Sellers			
Lancaster Junction			
Landisville (*d*) I	397	400	
Bruckhart's			
Ironville			
Kauffman's			
Chestnut Hill Summit	582	585	
Columbia (*e*) I	257	260	

c This summit comes in *somewhere* between Ephrata and Landisville.

d Crosses Pennsylvania R. R. *on grade.* It is given as 398 (405) in Table I, = a difference in the *Ocean Level* column of (5) feet.

e The Pennsylvania *Ocean Level* grade here is (251) at the depot on the street, lower down on the hill slope.

LIX. Lebanon and Tremont R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Lebanon Junction (*a*) LVII	(439)	(442)	
Heilmansdale	505	508	
Bunker Hill			
Jonestown			
Union Forge			
Swatara Gap			
Murray			
Mifflin			
Irving			
S. & S. R. R. Junc. (*b*) LXIII	491	494	
Pinegrove			
L. G. Ex. R. R. Junc. (*c*) (..)			
Tremont (R. R. Junc.) (*d*) (..)			
Donaldson	901	904	
Kalmia Colliery	1128	1131	

LX. Cornwall R. R.

NOTE.—The levels on the Cornwall Railroad were copied from a profile furnished by Mr. A. Wilhelm, President of the Company.

Reading R. R. datum, Mean Tide at Philadelphia. Add 3.349 feet for ocean level.

Lines have been surveyed south to Mount Hope, and to Manheim.

a Lebanon Valley R. R.

b Schuylkill and Susquehanna R. R.

c Lorberry Gap Extension R. R.

d Mine Hill R. R.; Lyken's Valley R. R.

STATIONS.	Mean Tide.	Ocean Level.
Lebanon Junction (*a*).....LVII	444	447
Cumberland Street.....	425	428
Plank Road.....	438	441
Killian's Road.....	534	537
Coleman's Road.....	534	537
Furnace Run.....	539	542
Cornwall (*b*).....	576	579

a Junction with Lebanon Valley R. R. near Lebanon.
b Opposite the Middle of the Ore Hill.

LXI. East Penn R. R.

STATIONS.	Mean Tide.	Ocean Level.
Reading (*a*).....L	(264)	(267)
Temple.....		
Blandon.....	405	408
Fleetwood.....		
Lyons.....	460	463
Bower's.....		
Topton Junction (*b*).....	471	474
Mertztown.....		
Shamrock.....		
Alburtis Intersection (*c*).....LV	427	430
Millerstown.....		
Emaus Station (*d*).....LIV	417	420
Penn Junction (*e*).....	260	263
Allentown.....		

a Reading R. R.
b Branch R. R. to Kutztown.
c Fogelsville R. R.—Colebrookdale R. R.
d Perkiomen R. R.
e Lehigh Valley R. R., just below Allentown, where the 260 (263) elevation is supposed to apply.

LXII. Little Schuylkill R. R.

STATIONS.	Mean Tide.	Ocean Level.
Port Clinton (*a*).....L	(397)	(400)
Drehersville.....		
Ringgold.....	541	544
Hecla.....		
Reynolds.....		
Tamaqua (*b*).....	787	790

a Reading R. R.
b South side of Broad Street.—Mountain Link and Schuylkill Valley R. R. —East Mahanoy R. R.

LXIII. Schuylkill and Susquehanna R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Auburn Junction (*a*).....L	(457)	(460)	
Jefferson.....			
Summit.....			
White Horse.....			
Stanhope			
Pinegrove Junction.....	511	514	
L. & P. R. R. Junction (*b*)..LIX	(491)	(494)	
Ellwood.			
Gold Mine.			
Rausch Gap			
Cold Spring			
Yellow Spring.....			
Rattling Run.			
Forge.....			
Dauphin (*c*).....			
Rockville (*d*).....I	(343)	(350)	

a Reading R. R.

b Lebanon and Pinegrove R. R., or Lebanon and Tremont.

c East side of the Susquehanna River.

d East side of Susquehanna River, crossing Pennsylvania R. R. at grade, at the east end of the long bridge, 5 miles above Harrisburg.

LXIV. Mine Hill and Schuylkill Haven R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Schuylkill Haven (*a*).....L	(520)	(523)	
Westwood Junction	654	657	
Summit	860	863	
Tremont.....	758	761	
Westwood Junction, as above....	(654)	(657)	
Minersville	684	687	
Mine Hill Gap.....	816	819	
Glen Carbon.....	1136	1139	
Head of Mine Hill Plane, No. 1 ..	1519	1522	
Foot of Gordon Plane.....	773	776	
Centralia.....CXV	1465	1468	
Potts Colliery, Locust Dale.....	1095	1098	

a Junction with Philadelphia and Reading R. R.

LXV. Catawissa and Williamsport R. R.

STATIONS.	Mean Tide.	Ocean Level.
Tamaqua (*a*).....LXVIII	(787)	(790)
East Mahanoy Junction (*b*).....	(1093)	(1096)
Tamenend (*c*).....	1291	1294
Quakeake Junction (*d*).....CXV	1350	1353
Summit.....	1542	1545
Girard.....		
Girard Passing.....		
Brandonville.....		
Ringtown.....	1332	1335
Beaver.....		
McAuley.....	759	762
Mainville.....	674	677
D. W. & H. R. R. (*e*).....CXVI	476	479
Catawissa.....	474	477
North Branch (*f*).....	481	484
Rupert (*g*).....		
Danville.....	493	496
Mooresburg.....		
Pottsgrove.....	494	497
Dougal.....	501	504
Milton.....		
P. & E. R. R. Crossing (*h*) CCXIII	480	483
Datesman's.....		
West Branch (*i*).....	475	478
New Columbia.....		
White Deer.....	486	489
Allenwood.....		
Fritz.....		
Montgomery.....		
P. & E. R. R. Crossing (*j*) CCXIII	500	503
Susquehanna River (*k*).....	505	508
Muncy.....	504	507
Hall's.....	521	524
Montoursville.....	534	537
Loyalsock Creek (*l*).....	535	538
P. & E. R. R. Crossing (*m*) CCXIII	542	545
Williamsport Depot (*n*).....	530	533

a b East Mahanoy R. R.

c Junction with Lehigh and Susquehanna Division of Central R. R. of N. J.

d With Lehigh Valley R. R.

e Crossing Danville, Hazelton and Wilkesbarre R. R. below Catawissa.

f Susquehanna River, water 29′ below rail.

g Junction with Lackawanna and Bloomsburg R. R.

h Crossing P. & E. R. R. (Milton).

i Susquehanna River, West Branch, water 28′ below rail.

j Crossing P. & E. R. R. (Montgomery).

k Water 30′ below rail.

l Water 13′ below rail.

m Crossing P. & E. R. R. (Williamsport).

n The level of the Philadelphia and Erie R. R. at this point is given in Table CCXIII, as 510.43 feet above Ocean Level.

LXVI. Mill Creek R. R.

STATIONS.	Mean Tide.	Ocean Level.
Pottsville (*a*).....L	(603)	(606)
Mount Carbon (*a*).....L	(591)	(594)
Mill Creek Junction.....	622	625
Port Carbon (*b*).....LXVII	627	630
Dormer's		
St. Clair.....		
Lanigan Furnace.....	706	709
John's Mines.....	827	830
New Castle.....	875	878
Head of Grade.....		
Frackville.....		

a a Philadelphia and Reading R. R.
b Junction with Schuylkill Valley R. R.

LXVII. Schuylkill Valley R. R.

STATIONS.	Mean Tide.	Ocean Level.
Pottsville (*a*) L		
Mt. Carbon (*a*) L		
Port Carbon (*b*).....LXVI		
Eagle Hill.....		
Cumbola.....		
New Philadelphia		
Middleport.....	712	715
Brockville.....		
Tuscarora.....	895	898
Newkirk.....		
Tamaqua (*c*).....LXII	(787)	(790)

a a Philadelphia and Reading R. R.
b Junction with Mill Creek R. R.
c Junction with Little Schuylkill R. R.

LXVIII. East Mahanoy R. R.

STATIONS.	Mean Tide.	Ocean Level.
Tamaqua (*a*).....LXII, LXV	(787)	(790)
East Mahanoy Junction.... LXV	1093	1096
" " Tunnel, south end	1312	1315
" " " north end	1334	1337
Mahanoy City Depot.....CXV	1235	1238

a End of Little Schuylkill R. R. Catawissa and Williamsport R. R.

LXIX. Mahanoy and Shamokin R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Head of Grade (*a*)	1472	1475	
Head of Mahanoy Plane	1479	1482	
Foot of Mahanoy Plane	1127	1130	
St. Nicholas Colliery	1155	1158	
New Boston Colliery	1520	1523	
Ashland Depot	881	884	
Summit	1155	1158	
Keystone	1025	1028	
Benjamin Franklin Colliery	1175	1178	
Locust Summit	1238	1241	
Monteliers Colliery	1072	1075	
Coal Ridge Colliery, No. 2	1131	1134	
Preston Colliery, No. 1	1090	1093	
Cuyler Colliery, Raven Run	1360	1363	
Girardville	1051	1054	
Shenandoah City Depot	1244	1247	
Head of Big Mine Run Plane	1275	1278	
Locust Gap Junction	1029	1032	
Greenback Colliery	895	898	
Shamokin Depot	730	733	
Trevorton Colliery	760	763	
Herndon Junction (*b*)	423	426	

a South side Broad Mountain Summit.

b Junction with Northern Central R. W. at Herndon Station, 13½ miles from Trevorton.

NOTE. There are scores of small branching colliery roads and tracks to coal mines not mentioned in the foregoing tables. Civil and mining engineers in the Coal Region are earnestly requested to furnish all the authentic levels of the intersections of such roads, levels of switches, levels of mouths of gangways, and levels of determinate recognizable points on the surface, high and low, in their possession, to make this portion of the hypsometrical records of Pennsylvania as complete and useful as possible. [J. P. L.]

LXX. Schuylkill Canal.

The elevations on the Schuylkill Canal, were copied from a list furnished by Mr. James F. Smith, Chief Engineer, Reading, Penna.

The datum is mid tide, Philadelphia. The levels are deduced from a survey made in 1846.

Schuylkill Navigation Company. Elevation of Combs of Dams.

NAMES OF DAM.	No.	Above Mid-Tide.	Ocean Level.	Name of Town.
Fairmount	32	10	13	
Flatrock	31	36.10	39	
Plymouth	30	45.87	49	Conshohocken.
Norristown	29	57.36	60	
Catfish	28	62.19	65	
Pawlings	27	66.49	69	Perkiomen.
Black Rock	26	84.61	88	Phœnixville.
Vincent	25	102.07	105	
Lewis	24	177.86	181	
Poplar Neck	23	184.88	188	Lower Reading.
Kissingers	22	204.38	207	
Shepps	21	213.09	216	
Leizes	20	221.46	224	
Felix's	19	236.27	240	
Herbine's	18	265.95	269	Leesport.
Kernsville	17	364.93	368	
Blue M'tn.	16	389.83	393	
Hummels	15	409.03	412	
Lords	14	432.98	436	
Cross Cut	13	443.93	447	Auburn.
Dam No.	12	451.23	454	
" "	11	471.53	475	
" "	10	476.93	480	
" "	9	483.33	486	
" "	8	490.63	494	
" "	7	509.23	512	Schuylkill Haven.
" "	6	551.38	554	
" "	5	574.36	577	Second Mountain.
" "	4	583.83	587	Mount Carbon.
" "	3	592.23	595	" "
" "	2	613.83	617	Palo Alto.
" "	1	618.63	622	Port Carbon.

NOTE.—Levels as taken from a profile in the Penna. Canal Co'.s Office, at Harrisburg, made under the direction of J. Dutton Steele, Civil Engineer, in 1851.

TOWNS.	Above Tide.		
Mount Carbon	620		
Schuylkill Haven	511		
Port Clinton	392		
Reading	195		
Pottstown	147		
Norristown	49		

LXXI. Union Canal.

The elevations on the Union Canal, were copied from a statement, giving number and lifts of locks, furnished through the kindness of Mr. B. B. Lehman, of Lebanon, Pa., formerly Chief Engineer and Genral Superintendent of the Union Canal.

Elevation of Locks on Union Canal from Lebanon, Eastward.

NO. OF LOCK.	Above Tide.	Ocean Level.
Lock No. 1	475.50	
" 2	471	
" 3	466.50	
" 4	462	
" 5	457.50	
" 6	453	
" 7	447.50	
" 8	440.50	
" 9	433.50	
" 10	427.50	
" 11	421.50	
" 12	414.50	
" 13	407.50	
" 14	401.50	
" 15	395.50	
" 16	387.50	
" 17	379.50	
" 18	373.50	
" 19	368.50	
" 20	362.50	
" 21	356.50	
" 22	351.50	
" 23	346.50	
" 24	340.50	
" 25	334.50	
" 26	328.50	
" 27	322	
" 28	315.50	
" 29	310.50	
" 30	305.50	
" 31	300.50	
" 32	295.50	
" 33	290.50	
" 34	285.50	
" 35	280.50	
" 36	275.50	
" 37	269.50	
" 38	264.50	
" 39	258.50	
" 40	253.50	
" 41	247.50	
" 42	241.50	
" 43	235.50	
" 44	230.50	
" 45	225.50	
" 46	220.50	
" 47	215.50	
" 48	210.50	
" 49	205.50	
" 50	200.50	
" 51	192.50	
" 52	185.50	
" 53	179	
" 54	169	

Lebanon (or Summit Level Union Canal) 480
Middletown (Mouth of Swatara Creek) 266
Reading (Schuylkill River) 169
Pinegrove (Basin at former head of Navigation) 483½

Elevation of Locks on Union Canal from Lebanon, Westward.

NO. OF LOCK.	Above Tide.	Ocean Level.
Lock No, 1	474.60	
" 2	469.20	
" 3	463.80	
" 4	458.40	
" 5	453	
" 6	447.60	
" 7	442.20	
" 8	436.80	
" 9	431.40	
" 10	426	
" 11	420.60	
" 12	415.20	
" 13	409.80	
" 14	404.40	
" 15	399	
" 16	393.60	
" 17	384.60	
" 18	376.60	
" 19	368.60	
" 20	362.60	
" 21	356.60	
" 22	351.10	
" 23	345.60	
" 24	340.10	
" 25	334.60	
" 26	329.60	
" 27	324.60	
" 28	319.60	
" 29	314.60	
" 30	309.60	
" 31	303.60	
" 32	297.60	
" 33	291.60	
" 34 (At Middletown)	285.60	
Susquehanna River } Mouth of Swatara Creek }	266	

LXXII. Lebanon Valley R. R. (Steele.)

NOTE.—This list was copied from a profile in the office of the Pennsylvania Company, at Harrisburg, made under the direction of J. Dutton Steele, Civil Engineer, in 1857.

STATIONS.	Above Tide.	Ocean Level.
Harrisburg I	314	
Hummelstown.....	362	
Palmyra	442	
Annville.....	395	
Lebanon	460	
Myerstown	468	
Womelsdorf	440	
Reading	253	
Birdsboro.....	165	
Pottstown.....	137	
Phœnixville.....	97	
Norristown.....	58	
Manayunk Falls.....	51	

III. LEHIGH SERIES.

C. North Pennsylvania R R

The levels on the North Pennsylvania R. R. were copied from the profile in the office of the Company, by permission of Mr. S. W. Roberts, Chief Engineer and General Superintendent.

The datum, or base of levels, is Philadelphia City datum, 8.733′ above mean surface of Atlantic Ocean. *Therefore 9 feet is added to make the second column.*

STATIONS.	City Datum.	Ocean Level.
Philadelphia Depot (*a*).....	19	28
Cohocksink	25	34
Diamond Street.....	30	39
Somerset Street.....	69	78
P. & R. Coal R. R. Crossing (*b*)..L	70	79
Tioga Street	94	103
Frankford Lane.....	92	101
Fisher's Lane.....	110	119
Green Lane.....	156	165
Oak Lane.....	192	201
City Line.....	184	193
York Road.....	176	185
Cheltenham Hills.....	181	190
Paxon's Road.....	225	234
Abingdon Junction (*c*).....CII	245	254
Edge Hill.....	284	293
Camp Hill.....	169	178
Edgehillville Road.....	167	176
Fort Washington.....	161	170
Ambler.....	190	199
Pennllyn.....	230	239
Gwynedd.....	262	271

a At Willow Street.

b Crossing Philadelphia & Reading R. R.

c Intersection of Northeast Pennsylvania R. R. at Abington.

STATIONS.	City Datum.	Ocean Level.
Wissahickon Creek	342	351
Lansdale Junc. (*d*).....CIII, CIV	359	368
Hatfield	302	311
Zetty's Road	339	348
Nigger Hill	443	452
Sellersville	322	331
Tunnel	444	453
Koffler's Gap	521	530
Bunker Hill	519	528
Quakertown	487	496
Hilltop	546	555
Coopersburg	540	549
Summit (*e*)	591	600
Koch's Mill	364	373
Yeager's Mill	339	348
Wagner's Mill	279	288
Hellertown	267	276
Hampton	267	276
Shimersville R.R. (*f*).....CV	255	264
Hess' Mill	259	268
Zinc Works	238	247
Bethlehem (*g*)	228	237

A profile in the office of the Pennsylvania Canal Company, at Harrisburg, made under the direction of J. Dutton Steele, Civil Engineer, in 1857, gives the following very different levels of some of the points mentioned in the above list, and of others not mentioned in it. Some of the names seem to have been altered or reversed:

Wingohocking (Frankford Lane?) 92; Fisher's Lane, 110; City Lane (Oak Lane?) 192; Edgehill (York Road?) 175; Edgehill, 284; Fort Washington, 158; Wissahickon (Ambler?) 190; Gwynedd, 229! North Wales, 377; Lansdale, 371; Nigger-Hill, 440; Sellersville, 311; Koffler's Gap, 524; Bunker Hill, 519; Quakertown, 489; Same's Gap, 597; Hellertown, 270; Bethlehem, 249.

The datum is "Tide."

CI. Delaware and Bound Brook R. R.

NOTE. For this road which is virtually a branch of the North Pennsylvania, leaving it at Jenkintown Station. See Appendix.

For the *Philadelphia and Newtown R. R.*, see under CLIII.

d Doylestown Branch and Stony Creek R. R. Crosses at Lansdale.

e Highest Point noted on profile of North Pennsylvania R. R. end of section 44, near Coopersburg, 591.50.

f Point of divergence of Shimersville Branch.

g The North Pennsylvania R. R. intersects the Lehigh Valley R. R. at this point.

CII. Northeast Pennsylvania R. R.

The levels on the Northeast Pennsylvania R. R. were furnished by Mr. S. W. Roberts, Chief Engineer and General Superintendent, N. P. R. R.

Base of levels, Philadelphia City datum, 8.733 above Ocean Level. Therefore nine feet is added to make second column.

STATIONS.	City Datum.	Ocean Level.
Abington Junction (*a*).....C	250	259
Summit.....	333	342
Willow Grove.....	250	259
Heaton.....		
Pennepack Creek.....	160	169
Fulmore.....		
Hatsborough.....	220	229
Hartsville.....	233	242

a Junction with the North Pennsylvania R. R. near Abington.

CIII. Doylestown Branch N. P. R. R.

The elevations on the Doylestown Branch of the North Penn R. R. were furnished by Mr. S. W. Roberts, Chief Engineer.

Base of levels, Philadelphia City datum, 8.733 above Ocean Level.

STATIONS.	City Datum.	Ocean Level.
Lansdale Junction (*a*).....C	359	368
Temperance Road.....	350	359
Neshaminy Creek.....	260	269
Road to Lexington.....	242	251
Cooke's Run.....	242	251
Bristol Road.....	294	303
Doylestown (*b*).....	338	347

a Point of divergence from N. P. R. R. at, or near Lansdale.
b Depot Ground at Doylestown.

CIV. Stony Creek R. R.

The levels on Stony Creek R. R. were copied from a profile furnished through the kindness of Mr. A. R. Roberts, Assistant Engineer, N. P. R. R.

The datum was fixed on the assumption that the elevation of the water in the Schuylkill River pool *below* Norristown, stood 49′ above Mean Tide at Philadelphia. The elevation of the comb of the dam *at* Norristown, as shown by the notes of the Schuylkill Navigation Company, at Reading, Pa., is 57.36′ above mid tide at Philadelphia.

The third column is made by adding three feet (3.349) to reduce to Mean Tide at Philadelphia to Ocean Level.

STATIONS.	Above Assumed Datum.	Mean Tide.	Ocean Level.	
Lansdale Junc. (*a*)....C	*350	†359	362	
1st Mile Post.....	350	359	362	
2d Mile Post.....	330	339	342	
Summit (*b*).....	350	359	362	
1st Crossing of Stony Cr.	215	224	227	
2d Crossing of Stony Cr.	142	151	154	
3d Crossing of Stony Cr.	104	113	116	
Norristown (*c*).....LI	50	59	62	

a With North Penn R. R. and with Doylestown Branch R. R.

* Elevation as shown on profile.

† Elevation of Railroad Crossing as shown on profile of North Penn. R. R. Levels at the other stations of the table are made to correspond with the level of North Penn R. R., by adding 9 feet to Mr. Roberts' original figures.

b Between Wissahickon and Stony Creek.

c The level given in Table LI, of the Philadelphia and Reading R. R., Germantown and Norristown Branch, at Norristown is 62 (65 Ocean Level).

CV. Shimersville Branch N. P. R. R.

STATIONS.	Above Tide.	Ocean Level.	
Junction (*a*).....C	255	258	
Junction (*b*).....CXIV	217	220	

a Point of divergence from N. P. R. R. near Bethlehem.

b Junction with Lehigh Valley R. R.

CVII. Lehigh and Susquehanna R. R.

NOTE.—This road runs on the north and east bank of the Lehigh River most of the way. Its levels are similar to those of the Lehigh Valley road on the opposite bank.

STATIONS.	Tide.	Ocean Level.	
Easton (*a*).....			
Freemansburg.....			
Bethlehem (*b*).....CXIII	(240)	(243)	
Allentown Station.....			
Catasauqua (*c*)			
Laubach's.....			
Siegfried's Bridge			
Treichler's.....			
Walnut Port.....			
Lehigh Gap			

a Junction with Morris & Essex R. R.

b Junction with N. Penna. and with Lehigh and Lackawanna R. R's.

c Junction with Cat. & Fogelsville R. R.

STATIONS.	Tide.	Ocean Level.	
Parryville			
Weissport			
Lehighton			
Mauch Chunk (*d*)			
Penn Haven Junction			
Rockport			
White Haven (*e*)			
Penobscot			
Ashley (*f*)			
Wilkesbarre			
Pittston			
Moosic			
Scranton (*g*)			
Green Ridge (*h*)			

CVIII. Mauch Chunk and Switch Back R. R.

Mauch Chunk			
Summit Hill			

CIX. Nesquehoning Valley R. R.

Mauch Chunk			
Nesquehoning			
Hauto			
Hometown			
Tamenend			

CX. Tamaqua Branch R. R.

Hauto			
Coledale			
Tamaqua			

CXI. Nescopec Branch R. R.

White Haven			
Upper Lehigh			

CXII. Nanticoke Branch R. R.

Ashley			
Sugar Notch			
Hanover			
Nanticoke			
Wanamie			

d Junction with Nesquehoning Valley Branch; M. C. Summit Hill and Switchback R. R.

e Junction with Nescopec Branch.

f Junction with Nanticoke Branch.

g Junction with Del. Lack. & Western R. R.

h Junction with Delaware & Hudson R. R.

CXIII. Lehigh and Lackawanna R. R.

The elevations on the Lehigh and Lackawanna R. R., were furnished by Mr. Charles Brodhead, President of the Company, who says, "Our surveys carry us into the *Wind Gap;* and the highest point on the Turnpike, *in the Gap*, we found to be 738 feet above Bethlehem, or 978 feet above tide." The road runs as far as Steuben, 15 miles.

STATIONS.	Mean Tide.	Ocean Level.
Bethlehem Junction (*a*)....CVII	240	243
Peter's Mills.....	255	258
Shimer's.....	287	290
Reiter.....		
Brodhead	315	318
Steuben	333	336
Bath	401	404
Chapman.....	576	579

a With Lehigh and Susquehanna R. R. at Bethlehem, on the north side of the Lehigh River.

CXIV. Lehigh Valley R. R.

The levels on the Lehigh Valley R. R. were copied from a list furnished by Mr. Robert H. Sayre, Chief Engineer and General Superintendent, Lehigh Valley R. R.

The datum is Mean Tide, Delaware River, three feet being added for Ocean Level in the second column.

Note on the Lehigh Canal Levels.

By a printed list of levels in the possession of Mr. George Ruddle, of Mauch Chunk, it appears that there is a rise in the

Lower grand section of Slackwater Navigation, from the Delaware River to Mauch Chunk (46 miles), of.....	360′.87
Upper grand section, Mauch Chunk to Wright's Creek (26 miles), of.	599′.83
Upper grand section, Wright's Creek to Stoddart's Ville (miles), of.....	336′.00
Adding to these figures, for the height of Bixler's Rift, Delaware Canal, above low tide in Delaware River.....	160.40
we get the following heights of the Lehigh Slackwater System:	
At Mauch Chunk, 360.87 + 160.40 = ...	521.23
At Wright's Creek, 521.23 + 599.83 = ...	1121.10
At Stoddart's Ville, 1121.10 + 336 = ...	1457.10

STATIONS.	Mean Tide.	Ocean Level.
Philipsburg (*a*).....CL	208	211
Delaware River, here.....	(148)	(151)
Easton	202	205
Redington.....		
Freemansburg.....	219	222

a 60′ above Delaware River, Junction with Central R. R. of N. J., Morris and Essex R. R., Belvidere and Delaware R. R.

STATIONS.	Mean Tide.	Ocean Level.
Bethlehem	231	234
North Penn R. R. Junction (*b*).C	247	250
East Penn R. R. Junction...LXI		
Allentown	251	254
Catasauqua.....CXV	277	280
Hokindauqua.....CXV *bis*		
Whitehall	297	300
Coplay		
Laury's	326	329
Slatington	363	366
Lehigh Gap	385	388
Lehighton	461	464
Mauch Chunk (*c*).....CVIII	553	556
Glen Onoko		
Penn Haven Junction.....CXVI	705	708
Hickory Run		
Rockport (*d*)	910	913
White Haven	1150	1153
Summit (*e*)	1742	1745
Fairview (*f*)	1675	1678
Newport	1024	1027
Warrior Run	710	713
Sugar Notch	670	673
South Wilkesbarre	550	553
Wilkesbarre (*g*)	553	556
Plainsville	550	553
Pittston.....CXVIII	572	575
Lackawanna Junction (*h*)....CLV	572	575
Ransom	584	587
Falls	590	593
McKunes'	600	603
Lagrange	600	603
Tunkhannock.....CXIX	614	617
Vosburg	617	620
Mehoopany	636	639
Meshoppen (*i*)	646	649
Black Walnut	653	656
Laceyville	663	666
Wyalusing	678	681
Frenchtown	694	697
Rumnerfield	700	703
Standing Stone	706	709
Wysauking	716	719
Towanda (*j*).....CXX	738	741
Ulster	743	746
Athen's Bridge	776	779
Waverly (*k*).....CLXII	823	826

b Junction with East Penn. R. R. Elevation given by Philadelphia and Reading R. R. at this point 260′.
c 40′ above Lehigh River.
d 35′ above Lehigh River.
e Nescopeck Mountain.
f Top of Wyoming Mountain.
g 30′ above Susquehanna River.
h 35′ above Susquehanna River, Junction with Delaware, Lackawanna and Western R. R.
i 35′ above Susquehanna River at Meshoppen.
j 28′ above Susquehanna River at Towanda.
k 25′ above Chemung River. At Waverly joins the New York and Erie R. R.

CXV. Catasauqua and Fogelsville R. R.

The levels of the Catasauqua and Fogelsville R. R. were furnished through the courtesy of Mr. Joshua Hunt, President of the Company.

The datum is Lehigh Valley R. R. at Catasauqua; which is 277′ above tide; and therefore 280′ above Ocean Level, as shown in the second column.

STATIONS.	Above Catasauqua.	Ocean Level.
Catasauqua	0	280
Seiple's	183	463
Jordan Bridge (*a*)	165	445
Guth's	209	489
Walbert	268	548
Chapman	259	539
Trexlertown (*b*)	129	409
Spring Creek	101	381
Alburtis (*c*)	173	453
Lock Ridge	158	438
Gardner	387	667
Red Lion	511	791
Rittenhouse Gap	658	938

a Water in creek at Jordan Bridge, 81 feet = Catasauqua; 361′ = Tide.
b Allentown R. R. Crossing on grade.
c East Pennsylvania R. R. Crossing.

CXV bis. Trenton R. R.

NOTE. No levels of this road could be obtained.

CXVI. Lehigh Valley Coal Branches.

The elevations on the Branch Railroads owned by the Lehigh Valley R. R. Company were furnished by Mr. Robert H. Sayre, Chief Engineer and General Superintendent.

The datum is mean Tide, Delaware River.

STATIONS.	Mean Tide.	Ocean Level.
Penn Haven Junction (*a*)	705	708
Black Creek (*b*)	1015	1018
Weatherly	1090	1093
Hazle Creek Junction (*c*)	1325	1328
Hazleton		
Eckley		
Hazel Creek Junction (*c*)	1325	1328
Beaver Meadow	1355	1358
Lewiston		
Jeanesville	1680	1683
Yorktown Crossing (*d*)	1750	1753

a With Lehigh Valley R. R.
b Leaves here the Quakeake R. R. or Mahanoy Division.
c Of the Beaver Meadow R. R. with the Hazleton R. R.
d Divide between the Lehigh and Susquehanna waters.

STATIONS.	Mean Tide.	Ocean Level.	
Audenreid	1735	1738	
Hartz's			
Quakake Junction (*e*)	1315	1318	
Delano (*f*)	1665	1668	
Mahanoy City Junction.....LXV	1552	1555	
Mahanoy City.....LXVIII	1230	1233	
Shenandoah	1268	1271	
Raven Run			
Centralia (*g*).....LXIV	1484	1487	
Mount Carmel	1056	1059	
Locust Gap	1027	1030	
Fulton	960	963	
Shamokin (*h*)	730	733	
Zerbe Summit (*i*)	1073	1076	
Zerbe Colliery	905	908	

e Crosses at Yorktown the Catawissa R. R. Elevation (as given by Philadelphia and Reading R. R. at this point) 1350′ feet above tide!

f Delano is on the divide between Schuylkill and Susquehanna waters.

g Centralia is on the divide between the Mahanoy and Shamokin waters.

h Shamokin Station 70′ above the town.

i Zerbe Summit divides the Shamokin and Little Mahanoy waters.

CXVII. Danville, Hazleton and Wilkesbarre R. R.

The elevations on the Danville, Hazleton and Wilkesbarre R. R. were furnished by Mr. A. B. Starr, Assistant Engineer, P. & E. R. R.

The datum is *high* tide at the Schuylkill River, at Philadelphia. Add seven feet for Ocean Level.

STATIONS.	High Tide.	Ocean Level.	
Sunbury Junction (*a*)	436	443	
Kline's Grove	438	445	
Wolverton	435	442	
Kipp's Run	456	463	
Danville (*b*)	456	463	
Roaring Creek	452	459	
Catawissa	464	471	
R. R. Crossing (*c*)	463	470	
Mainville	582	589	
Mifflin Cross Roads	804	811	
Scotch Valley	1008	1017	
Summit	1030	1037	
Wolfton	1016	1023	
Rock Glen	914	921	
Gowan	992	999	
Tomhicken (*d*)	1221	1228	

a Shamokin R. R. with Northern Central R. R. at Sunbury.

b With Lackawanna and Bloomsburg R. R.

c Catawissa R. R. Crossing; Elevation of Catawissa R. R. at same point 476.

d With Lehigh Valley R. R.

CXVIII. Pennsylvania Coal Company's R. R.

Elevations on the Pennsylvania Coal Company's R. R. from Pittston (or Port Griffith) to Hawley were copied from a profile in the Company's office at Pittston, Pa., by permission of Mr. George Johnson, Engineer.

The datum is 0 at foot of Plane No. I = 567.'28 above Sea Level.

	STATIONS.	Profile.	Above Tide.
	Head of Plane.....No. 1	108	675
Loaded track going out from Pittston.	" " ..... " 2	206	773
	" " ..... " 3	246	813
	" " ..... " 4	397	964
	" " ..... " 5	495	1062
	" " (Dunmore) " 6	550	1117
	" " ..... " 7	697	1274
	" " ..... " 8	888	1455
	" " ..... " 9	1077	1644
	" " ..... " 10	1255	1822
	" " ..... " 11	1217	1784
	Tunnel	1400	1967
	Base of Plane.....No. 12	779	1346
	Head of Plane.....No. 12	928	1495
	Hamlin	329	896
	Head of Plane.....No. 13	511	1078
Empty track back to Port Griffith's.	" " ..... " 14	640	1207
	" " ..... " 15	733	1300
	" " ..... " 16	830	1397
	" " ..... " 17	874	1441
	" " ..... " 18	955	1522
	" " ..... " 19	998	1565
	" " ..... " 20	952	1519
	" " ..... " 21	1040	1607
	" " ..... " 22	246	813
	Foot of Plane ..... " 22	64	631

CXIX. Montrose R. W.

Elevations on the Montrose Railway were furnished by Mr. James I. Blakslee, President of the Company.

The datum, or base of levels, is that of grade on the Lehigh Valley R. R. at Tunkhannock.

STATIONS.	Mean Tide.	Ocean Level.
Tunkhannock (*a*).....CXIV	614	617
Marcy.....	968	971
Lemon.....	1044	1047
Avery.....	982	985
Meshoppen Creek.....	936	939
Lynn.....	1035	1038
Springville.....	1260	1263
Tylersville.....	1403	1406
Dimock.....	1510	1513
Hunter's.....	1550	1553
Cool's.....	1550	1553
Allenville.....	1652	1655
Montrose.....	1659	1662

a Junction with Lehigh Valley R. R.

CXX. Barclay and Schrader R. R.

Elevations on the Barclay and Schrader R. R's were furnished by Mr. A. W. Stedman, Engineer of the Pa. & N. Y. R.R. & Coal Co., at Towanda, Pa., through the solicitation of Mr. James Macfarlane.

The datum is mean tide at Philadelphia.

STATIONS.	Mean Tide.	Ocean Level.
Towanda (*a*).....CXIV	732	735
Towanda (*b*).....	719	722
Monroeton Junction (*c*)....CXXI	756	759
Masontown (*d*).....	788	792
Greenwood.....	817	820
Lamoka.....	1036	1039
Foot of Plane (*e*).....	1265	1268
Head of Plane (*f*)	1750	1753
Schrader R. R.*		
R. R. Switch (*g*).....	1795	1798
R. R. Switch (*h*).....	1782	1785
Carbon Run (*i*).....	1923	1926
Lowest Point (*j*).....	1970	1973
Summit	2035	2038

*This Railroad, four miles long, connects the Barclay R. R. with the Schrader Coal Mines.

a Switch at Upper Depot.
b Barclay Depot.
c With State Line and Erie R. R.
d Barclay R. R. Bridge rail.
e *Elevation estimated.*
f Rail in Plane-house.
g Upper Switch connecting with Barclay R. R.
h Lower Switch connecting with Barclay R. R.
i Rail under Breaker is 1923′.
j Lowest Point of Coal near Breaker.

CXXI. State Line and Erie R. R.

Levels on the State Line and Erie R. R. were copied from a profile in the office of the Company at Towanda, Bradford County, Pa. There were no stations, or names of towns, noted on the profile, the elevations being marked at mile posts, and therefore, the stations have been located from J. A. Anderson's R. R. map. The levels as shown in this list may not be entirely correct; but it is the only record which could be found.

The datum is Mean Tide at Philadelphia.

STATIONS.	Mean Tide.	Ocean Level.
Monroeton Junction (*a*).....CXX	756	759
Wilcox.....	1117	1120
New Albany.....	1191	1194
Miller's	1324	1327
Bushore.....(?)	1587	1590
Bernice	1852	1855

a With Barclay R. R.

IV. DELAWARE SERIES.

CL. Philadelphia and Trenton R. R.

Levels on the Philadelphia and Trenton, and Belvidere Division of the Pennsylvania R. R. were furnished by Mr. F. B. Fiddler, Engineer in the office of the Company at Trenton, N. J. The levels were deduced from the original table of grades by Samuel H. Kneass, Engineer.

The datum of the Philadelphia and Trenton R. R. is mean tide at Philadelphia. The datum of the Belvidere Division of the Pennsylvania R. R. is water in canal at junction of feeder with Delaware and Raritan Canal near Trenton, which water level is four feet below the railroad track.

Philadelphia, Trenton and Belvidere Division, Pennsylvania R. R.

STATIONS.	Mean Tide.	Ocean Level.
Philadelphia		
Kensington (*a*)	29	32
Bridge over Frankford Creek	24	27
Frankford Station (*b*)	29	32
Bridesburg (*c*)	29	32
Tacony	31	34
Bories	32	35
Cornwell's	36	39
Eddington (*d*)	39	42
Bristol (*e*)	18	21
Tullytown	17	20
Penn Valley	18	21
Morrisville (*f*)	31	34
Trenton Junction (*g*)	60	63
Washington's Crossing	64	67
Prime Hope Saw Mills	CLI	
Lambertville	72	75
Prallsville	83	86
Bull's Island (*h*)	94	97
Warford's Rock	CLI	
Frenchtown	125	128
Milford	137	140
Holland	CLI	
Reigelsville	163	166
Carpenterville	175	178
Phillipsburg (*) CXIV	195	198
Martin's Creek	231	234
Belvidere	268	271
Manunka Chunk	320	323
Walker's Ferry Water Gap	CLI	

a Frankford Road Crossing.

* Lehigh Valley R. R.

b Middle of Church Street.

c Middle of Bridge Street.

d Dunk's Ferry Road.

e Middle of Market Street.

f N. E. side of Washington Street.

g The railroad track is four feet above the water in the canal.

h Elevation of railroad, head of Bull's Island, 97′. Low water in Delaware River 74′.

CLI. Delaware River Levels.

NOTE.—The following levels of ordinary low water in Delaware River above *mean tide at Philadelphia* (– 3.349 above mean ocean level) were obtained in the office of the Philadelphia and Trenton R. R. at Trenton, from Mr. F. B. Fiddler, C. E., deduced from the original grade tables by Mr. S. H. Kneass.

PLACES.	Mean Tide.	Ocean Level.
Trenton		
Washington's Crossing	20	23
Prime Hope Saw Mills	35	38
Lambertville	49	52
Bull's Island	71	74
Head of Bull's Island	74	77
Warford's Rock	91	94
Frenchtown	104	107
1.7 miles above " (*a*)	107.7	111
Milford	111	114
4 miles above " (*b*)	121.8	125
Holland	116	119
1½ miles below Reigelsville	124.2	127
Reigelsville	127	130
⅜ mile above "	130	133
1.6 mile above "	133.8	137
Carpenterville	137	140
2½ miles below Phillipsburg (*c*)	148.6	151
Phillipsburg	157	160
1¾ mile above "	165.2	168
2.7 miles above "	170.4	173
7.6 miles above "	192.8	196
2.84 miles above Martin's Cr. (*d*)	200.4	204
4.14 miles above "	210.9	214
Belvidere	232	235
Manunka Chunk	262	265
Walker's Ferry at Delaware Water Gap	298	301

CLII. Delaware Canal.

Elevations on the Delaware Canal were copied from a map made under the direction of the Lehigh Coal and Navigation Company, in 1826, by Isaac A. Chapman. The map is in possession of Mr. George Ruddle, Mauch Chunk.

The datum is low tide Delaware River, 3.349 above Ocean Level.

a Huntingdon County, N. J., 31.7 miles above Trenton.
b " " " not the Milford of Pike County, Pa.
c Opposite Easton, in New Jersey.
d Above Easton, in Pennsylvania.

POINTS ON LINE OF CANAL.	Low Tide. Feet.	Inches
Trenton Falls; head; 49 miles below the mouth of Lehigh River	9	8
Gould's Rift; head	16	8
Yardleyville	18	
Scudder's Rift; head	24	8
Taylor's Rift; head	33	6
Buck Tail Rift; head	36	5
Will's Falls; head	49	9
New Hope	50	
33 miles below Lehigh River	53	3
Green Banks Rift; head	58	9
Gallopen's; head	68	3
Bull's Falls; head	72	2
26 miles below Lehigh River	72	9
Cut Bite Rift; head	77	4
Tumbling Dam Falls; head	89	1
Marshal's Island Rapids; head	100	7
Man of War Rift; head	102	3
Stunt's Falls; head	107	2
Firman's Falls; head	110	11
Nockamixon Falls; head	117	6
Linn's Falls; head	124	10
11 miles below Lehigh River	126	10
10 miles below Lehigh River	127	3
Durham Falls; head	130	3
9 miles below Lehigh River	130	4
Greavelly Falls; head	133	3
Rocky Falls; head	136	1
Ground Hog Rift; head	138	1
Old Sow Rift; head	145	7
Clifford's Rift; head	150	10
Bixler's Rift; head (*a*)	160	5

a This point is about one-half mile below the mouth of Lehigh River.

CLIII. Philadelphia and Newtown R. R.

NOTE.—See Appendix.

CLIV. Flemington R. R.

Levels on the Flemington R. R. were copied from a list prepared by Mr. F. B. Fiddler, in the R. R. office, at Trenton, N. J.

The datum is mean tide Delaware River, = 3.349 above Ocean Level.

STATIONS.	Mean Tide.	Ocean Level.	
Flemington Junction (*a*).....CL	73	76	
Mount Airy	147	150	
Ringoes	248	251	
Summit (*b*)	255	258	
Copper Hill	159	162	
Flemington	183	186	

a Junction with Belvidere and Delaware R. R.

b N. E. of Ringoes.

NOTE.—Two other short lists in New Jersey are here appended, on account of their connections with the Delaware River lines. Other New Jersey Railway levels are published by Prof. Cook in his Annual Reports of the Geological Survey of that State.

Morris and Essex R. R.

The Morris and Essex R. R. levels were furnished by Mr. James Archbald, Chief Engineer, Del. L. & W. R. R.

STATIONS.	Mean Tide.	Ocean Level.	
Phillipsburg.....CL	217	220	
Phalcony Creek.....	341	344	
Stewartsville.....	370	373	
Washington Depot.....	503	506	
Port Murray.....	585	588	

Belvidere and Newtown R. R.

NOTE.—The Belvidere and Newtown levels were copied from a list furnished by Mr. F. B. Fiddler, Trenton, N. J.

STATIONS.	Mean Tide.	Ocean Level.	
R. R. Junction (*a*).....CL	272	275	
Belvidere.....	283	286	
Sarepta.....	361	364	
Hope.....	478	481	
Howell P. O.....	562	565	
Summit.....	595	598	
Johnsburg.....	568	571	
Summit.....	628	631	
Newton.....	607	610	

a Junction with B. D. R. R.

CLV. Delaware, Lackawanna and Western R. R.

Elevations on the D. L. & W. R. R. were copied from a profile in the office of the Company at Scranton, by permission of the Assistant Engineer, Mr. Bryson.

The datum is mean tide, Delaware River, = 3.349 above Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	Corrected.
Junction (Central R.R. of N. J)..			
Washington (Morris & Essex R.R.)			
Oxford Furnace.....			
Bridgeville.....			
Manunka Chunk.....CL			
Delaware Bridge.....	290	293	
Portland.....	288	291	
Delaware Water Gap.....	316	319	

STATIONS.	Above Tide.	Ocean Level.	Corrected.
Stroudsburg	400	403	
Spragueville	487	490	
*Henryville	593	596	
*Oakland	1008	1011	
*Paradise	1518	1521	
Forks			
Tobyhanna (*a*)	1929	1932	
Gouldsboro			
Summit	1887	1890	
*Moscow	1555	1558	
*Dunning's	1397	1400	
Greenville	1182	1185	
Scranton.....CLVI, CXVIII	740	743	
Clark's Summit	1239	1242	
Abington	1055	1058	
Factoryville	917	920	
Tunnel	963	966	
Nicholson	766	769	
Hopbottom	890	893	
Foster			
Oakley's	942	945	
Montrose Station	1050	1053	
New Milford	1084	1087	
Great Bend	876	879	
State Line	860	863	
Corbettsville	852	855	
Conklin	849	852	
Binghamton.....CLXII	843	846	

a The highest point noted on the profile, 1970 feet above tide. This point is between Tobyhanna & Summit.

* Elevations at stations marked thus (*) were not marked on the profile; neither could it be exactly determined what was the vertical scale of the profile; but it was supposed to be 290 feet to the inch.

The following list is therefore added, some of its figures corresponding exactly with those above. It was obtained from a profile in the office of the Pennsylvania Canal Co., at Harrisburg, made under the direction of J. Dutton Steele, in 1851.

STATIONS.	Above Tide.	Ocean Level.	
White House	170	173	
Lebanon	274	277	
Clinton	326	329	
New Hampton Summit	505	508	
West End Switch	498	501	
Delaware Bridge	293	296	
Delaware Water Gap	314	317	
Stroudsburg	422	425	
Naglesville	1961	1964	
Greenville	1182	1185	
Scranton	739	742	

CLVI. Bloomsburg Division, D. L. & W. R. R.

Elevations of the Bloomsburg Division of the Delaware, Lackawanna and Western R. R. were copied from notes, in the possession of Mr. A. Bryson, Jr., Div. Engineer, at Scranton, Pa. This list contains all the levels that could be obtained of this road.

STATIONS.	Mean Tide.	Ocean Level.
Scranton.....CLV	740	743
Taylorville.....	683	686
Lackawanna Junction.....	573	576
Pittston.....	573	576
West Pittston.....	580	583
Wyoming.....	560	563
Maltby.....	560	563
Kingston.....	551	554
Plymouth Junction.....	545	548
Plymouth.....	539	542
Avondale.....	534	537
Nanticoke.....		
Hunlock's Creek.....		
Schickshinny.....		
Beach Haven.....		
Berwick.....		
Brier Creek.....		
Espey.....		
Bloomsburg.....		
Rupert.....		
Catawissa Bridge.....		
Danville.....		
Northumberland.....		
Sunbury.....		

CLVII. Lackawanna R. R.

Elevations on the Lackawanna R. R. between Carbondale and Scranton were furnished by Mr. A. H. Vaudling, Superintendent Delaware and Hudson Canal Co.'s R. R. at Providence, Luzerne County, Pa.

The datum is "Tide;" but whether high tide or mean tide is not known. Supposing it to be *mean* tide, 3.349 feet is added for Ocean Level.

STATIONS.	Above Tide.	Ocean Level.
Carbondale (*a*).....CLX	1083	1086
Jermyn.....	968	971
Archbald.....	965	968
Olyphant.....	807	810
Providence (*b*).....	700	703

a Coal Brooke Breaker in Carbondale. The *canal level* at Carbondale is given by J. D. Steele as 965; see Table CLVIII.

b Elevation at the Lackawanna.

CLVIII. Carbondale & Honesdale R. R.

Levels on the Carbondale and Honesdale Railroad are in accordance with a profile furnished by Mr. A. H. Vandling, Superintendent of the Delaware and Hudson Canal Company, office of coal department, at Providence Penna. According to the profile which is marked, "Profile B, New Road," the *loaded* track starts from Carbondale at a point marked 1012 feet above tide; and the *empty* track starts at a point marked Honesdale 1000 feet above tide. In J. D. Steele's list (CLVIII) Carbondale and Honesdale are both alike called 965′ above tide, at the level of the canal.

	STATIONS.	Above Carbondale.	Above Tide.	
Loaded cars, eastward.	Carbondale, lower end.....	00	1012	
	Head of Plane 1.....	240	1252	
	Head of Plane 2.....	377	1389	
	Head of Plane 3.....	579	1591	
	Head of Plane 4.....	762	1774	
	Head of Plane 5 (*a*)	923	*1935	
	Head of Plane 6.....	906	1918	
	Head of Plane 7.....	572	1584	
	Foot of Plane 7 (*b*).....	440	1452	
Empty cars back.	Honesdale.....CLIX	00	1000	1003
	Head of Plane 1.....	180	1180	1183
	Head of Plane 2.....	178	1178	1181
	Head of Plane 3.....	290	1290	1293
	Head of Plane 4.....	424	1424	1427
	Head of Plane 5.....	502	1502	1505

CLIX. Honesdale Branch Erie Railway.

STATIONS.	Above Tide.	Ocean Level.	
Honesdale.....CLVIII	966		
White Mills.....	925		
Hawley	899		
Kimbles.....	849		
Millville	780		
Rowlands	700		
Lackawaxen	650		

CLX. Delaware and Hudson Canal.

This list is from J. Dutton Steele's profile of 1851, in Penna. Canal Co'.s office, at Harrisburg.

TOWNS.	Above Tide.	Ocean Level.	
Carbondale.....CLVII	965		
Honesdale.....	965		
Hawley.....	880		
Port Jarvis.....	455		
Port Clinton.....	455		

a Summit.
b From this point to Honesdale, a distance of 10 miles, there is a regular descent of 44 feet to the mile.

CLXI. Jefferson Branch, Erie Railway.

STATIONS.	Above Tide.	Ocean Level.
Lanesboro Junction (*a*)....CLXII	982	
Ninevah Junction	981	
Brandts	1047	
Stevens Point	1078	
Webster's Mills	1297	
Starrucca	1424	
Thompson	1703	
Ararrat Summit	2023	
Herrick Centre	1803	
Uniondale	1693	
Forrest City	1481	
Carbondale	1079	

a With the Erie Railway at Lanesboro, in Susquehanna Co., Pa., about 190 miles from New York City. This road runs south to the Anthracite Coal field.

CLXII. Erie R. R. Line.

Levels on the Erie Railway were copied from profiles furnished by Mr. H. D. Blunden, Assistant Engineer. The profiles are complete, embracing the main line of road from Jersey City to Dunkirk, and all branches owned by the Erie Railway Company.

The datum is tide water at Jersey City. This, if *mean tide*, may be considered equivalent to Ocean Level.

Erie R. R.—Delaware Div.

STATIONS.	Above Tide.	Ocean Level.
Port Jervis	440	
Pond Eddy	571	
Shoholo	648	
Lackawaxen....CLX	648	
Pine Grove	668	
Narrowsburg	714	
Nobodys	748	
Cohecton	748	
Callicoon	781	
Rock Run	787	
Hawkins	809	
Basket	830	
Bouchon	850	
Lordville	864	
Stockport	896	
Hancock	926	
Dickinsons	954	
Hales Eddy	974	
Deposit	1009	
Summit	1373	
Susquehanna....CLXI	914	

Erie R. R.—Susquehanna Div.

Great Bend	884
Binghamton.....CLV	868
Hooper	839
Union	834
Campville	830
Owego	822
Tioga	805
Smithboro	799
Waverly	836
Chemung	820
Wellsboro	831
Elmira	863
Corning.....CLXIV	942
Painted Post	947
Erwins	983
Addison	993
Rathboneville	1015
Cameron Mills	1029
Cameron	1056
Santees	1067
Adrian	1112
Canesteo	1134
Hornellsville	1161

Erie R. R.—Western Div.

Tip Top Summit	1783
Andover	1676
Genessee	1511
Scio	1458
Philipsville	1390
Belvidere	1384
Friendship	1539
Cuba Summit	1698
Cuba	1542
White House	1514
Hindsdale	1501
Olean	1438
Allegheny	1422
Vandalia	1415
Carrollton.....CLXVI	1399
Great Valley	1393
Salamanca	1384
Little Valley	1594
Cattaraugus	1411
Persia	1390
Smith's Mills	1010
Forestville	883
Dunkirk (*a*)	600

a The elevation given at Dunkirk by Lake Shore and Michigan Southern R. R., is 24.94 + 573. L. Erie = 597.94.

CLXIII. Erie R. R.—Buffalo Div.

STATIONS.	Above Tide. Ocean Level.
Arkport	1199
Burns	1203
Caneseraga	1260
Garwoods	1280
Swains	1312
Turnout	1319
Nunda	1336
Hunts	1339
Portage	1314
Castile	1401
Gainesville	1407
Warsaw	1326
Dale	1178
Linden	1181
Attica	998
Tonawanda	1003
Summit	1086
Griswold	1044
Darien	1024
Alden	868
Town Line	742
Lancaster	683
Checktowga	661
East Buffalo	611
Buffalo	588

CLXIV. Corning, Cowanesque & Antrim Railway.

The levels on Corning, Cowanesque and Antrim Railway, were furnished by Mr. A. H. Gorton, Supt. The levels on this road have been reduced to the datum of the New York and Erie Railway, by adding 26 feet to Mr. Gorton's figures.

STATIONS.	Tide.	Corrected Tide.
Corning.....CLXII	*918	†942
Ernin Centre	952	976
Lindley	973	997
Lawrenceville.....CLXV	982	1006
Nelson	1162	1186
Elkland	1118	1142
Lawrenceville.....CLXV	982	1006
Tioga Village	1028	1052
Holliday	1127	1151
Middleburg	1154	1178
Niles Valley	1168	1192
Wellsboro	1295	1319
Summit	1838	1862
Antrim Coal Mines	1648	1672

* Grade at Corning Junction according to Mr. Gorton.

† Grade at Corning Junction by profile of Erie Railway.

CLXV. Tioga R. R.

Levels on the Tioga R. R. were furnished by Mr. S. B. Elliott, Engineer of the T. R. R.

The datum is asserted to be that of the Erie R R. at Corning; in other words the following figures have been constructed on the basis of the Erie R. R. list, without reference to Mr. Gorton's intermediate station levels.

STATIONS.		Above Tide.	Ocean Level.
Lawrenceville.....CLXIV		1006	
Somer's Lane		1018	
Mitchell's Creek.....		1022	
Old Station		1035	
Tioga.....		1042	
Mill Creek		1077	
Lamb's Creek.....		1111	
Mansfield.....		1140	
Canoe Camp.....		1163	
Covington.....		1208	
Blossburg.....		1348	
Morris Run (*a*).....		1678	
Arnot (*b*).....		1682	
Fall Brook (*c*).....		1842	

a, *b*, *c* Coal Mines in the Blossburg Basin.

CLXVI. Bradford Branch, Erie Railway.

STATIONS.	Above Tide.	Ocean Level.	
Carrollton Junction (*a*)....CLXII	1400		
Ernins Mills	1409		
Limestone.....	1415		
Babcock.....	1429		
Bradford	1464		
DeGolias	1510		
Big Shanty	1715		
Crawfords	2098		
Summit (*b*).....	2140		
Alton	2080		
Gilesville.....	2016		

a With the Erie R. R., 407 miles from New York. This road runs south to the coal fields of McKean Co., Pa.

b Highest point on the profile just south of Crawfords.

V. SUSQUEHANNA SERIES.

CC. Northern Central.

Levels on the N. C. R. R. were copied from an old lithographed profile in the office at Baltimore, Md.

Datum: Mean tide at Baltimore; equivalent to + Ocean level.

STATIONS.	Mean Tide.	Ocean Level.	
Baltimore			
B. & P. R. R. Junction			
Mount Vernon	131		
Green Spring Junction (*a*) CCLV			
Timonium	381		
Cockeysville			
Sparks			
Monkton			
Parkton	420		
Freelands	596		
New Freedom	827		
Seitzland	611		
Glen Rock	551		
Hanover Junction (*b*)	422		
Smysers	389		
Glatfelter's	335		
Tunnel	299		
York (*c*) CCVI, CCVII	366		
Emigsville	376		
Mount Wolf	376		
Summit, No. 2	466		
Conewago Bridge	289		
York Haven	291		
Goldsboro	304		
Middletown Ferry	307		
Marsh Run	307		
New Cumberland	312		
Bridgeport (*d*) CCIX	355		
Marysville	350		
Dauphin (*e*) LXIII			
Clark's Ferry	361		
Halifax	378		
Liverpool			
Mohontongo			
Millersburg (*f*) CCXI	396		
Georgetown	417		
Trevorton Junction (*g*) LXIX	428		
Fisher's Ferry	433		
Selinsgrove	438		
Sunbury (*h*) CCXV	444		

a With Green Spring Branch N. C. R. R.

b With Hanover Branch, Han. & Gett. R. R.

c Junction with Peach Bottom R. R. and with York and Columbia R. R., and York & Gettysburg R. R.

d Opposite Harrisburg. Junction with Cumberland Valley R. R.

A list of levels of some of the above named points made by J. D. Steele, in 1851, was obtained in the office of the Penna. Canal Co., at Harrisburg, and is given for comparison, as follows:

STATIONS.	Mean Tide.	Ocean Tide.	
Mellvale	168		
Timonium	395		
Ashland	269		
Monckton	344		
Parkton	430		
Summit	860		
Glenrock	556		
Glatfelter's	472		
York	373		
Conewago Creek	285		
Bridgeport	343		
Dauphin	332		
Halifax	360		
Lykens V. R. R. Junction	380		
Millersburg	382		
Georgetown	417		
Sunbury.....CCXV	429		

CCI. Tide Water and Susquehanna Canal.

Levels on the T. W. & S. Canal, were copied from a profile in the office of the Schuylkill Navigation Company, at Reading, Pa., by permission of Mr. James F. Smith, Chief Engineer.

Datum, *low tide* at Havre de Grace. Information on the spot leads to the belief that the tide rises here 2½ feet.

Tide Water Canal.

STATIONS.	Above Low Tide.	Ocean Level.	
Level of Chesapeake Bay	0		
Lock No. 9, surface of water	10		
Lock No. 8, " "	16		
Lock No. 7, " "	26.5		
Lock No. 6, " "	37		
Lock No. 5, " "	47		
Lock No. 4, " "	57		
Lock No. 3, " "	67		
Lock No. 2, " "	77		

e Junction with Schuylkill and Susquehanna R. R.

f Junction with Lykens Valley Coal R. R. (Summit Branch R. R.)

g With Mahanoy and Shamokin Branch P. & Reading R. R.

h Junction 1. With Shamokin Division R. R. (CCXIV). 2. With Danville Hazleton and Wilkesbarre R. R. (CXVII). 3. With Philadelphia & Erie R. R. (CCXV). Note. The cars of the Northern Central run on the P. & E. R. R. to Williamsport, and then on the leased line from Williamsport to Canandaigua, once called the Williamsport and Elmira R. R., and now known as the northern extension of he Northern Central R. R.

Susquehanna Canal.

Lock No. 19, (next to No. 2, T. W. C)	85
Lock No. 18, upper level	93
Lock No. 17, " "	103
Lock No. 16, " "	114
Lock No. 15, " "	123
Lock No. 24, " "	125
Lock No. 23, " "	134
Lock No. 22, " "	143
Lock No. 22, " "	152
Lock No. 20, " "	161
Lock No. 9, " "	170
Lock No. 8, " "	177.5
Lock No. 7, " "	185
Lock No. 6, " "	193
Lock No. 5, " "	201
Lock No. 4, " "	209
Lock No. 3, " "	217
Lock No. 2, " "	225
Lock No. 1, " "	233
Aqueduct across Cabin Branch Creek	233
Grand Lock at Wrightsville, opposite Columbia	233

CCII. Pennsylvania Canal, E. D.

Elevations on the Pennsylvania Canal, Eastern Division, were furnished by Mr. Thos. T. Wierman, Jr.

Datum is *mean tide*, Chesapeake Bay.

STATIONS.	Mean Tide.
Columbia Dam, surface	221
Canal Basin, (Columbia)	236
Susquehanna River below Conewago Falls	244
Susquehanna River above Conewago Falls	263
Harrisburg Canal Basin (*a*)	312
Clark's Ferry Dam	333

a Surface of water in the large (Porter's) Basin at Harrisburg 320

Floor of vestibule of the State Capitol at Harrisburg 361

CCIII. Juniata Division Pennsylvania Canal.

Juniata River, Mouth :—	
Mitre Sill of Stop Lock at Junction. CCIV	347
Millerstown dam, surface	376
Lewistown dam, "	442
Canal at Lewistown "	450
Anghwick dam, "	492
Canal at Huntingdon "	586
Huntingdon :	
Lower Mitre Sill of Lock No. 40	599

CCIV. West Branch Division Pennsylvania Canal.

Juniata River, Mouth :—(*b*)	
Mitre Sill of Stop Lock at Junction.....CCIII	347
Liverpool, water in River	368
Liverpool, water in Canal	381
Water in	
River below Shamokin dam ...	411
Shamokin dam, at Sunbury....	419
Canal at Northumberland..CCV	432
Lewisburg dam (*c*).....	424
Canal opposite Lewisburg.....	445
Muncy dam	459
Loyalsoch dam and Canal.....	502
Canal at Williamsport	509
Lock Haven dam.....	540
Queens Run dam.....	546
Bald Eagle dam.....	559

b Surface of water of Pool of dam at Duncan's Island 332

c This dam has no connection with the Canal, and is therefore at a lower level.

CCV. Wyoming Division Pennsylvania Canal.

Northumberland; canal levelCCIV	432
Bench Mark at Northumberland..	434
Danville ; canal level	443
Bloomsburg ; canal level.....	470
Below Berwick ; canal level	480
Shickshinny ; canal level.....	500
Nanticoke dam	504
Wilkesbarre ; canal level.....	534
Water in river above Wilkesbarre	511
Top of coping Plainsville Lock...	541

CCVI. Peach Bottom R. R.

Levels of the Peach Bottom R. R. were copied from notes in the office at York.

Datum: Susquehanna River at Peach Bottom, on the assumption that the water in the river at Peach Bottom stood at 85.88 feet above tide.

According to the profile of the Frederick Division of the Pa. R. R., the elevation of York above tide at Baltimore, is 364.6 feet. This is the latest determination. Sixteen feet have therefore been substracted to make the second column.

This R. R. is a 3 foot or "Narrow Guage," and connects with the Northern Central R. R. at York.

STATIONS.	Assumed Datum.	Corrected Tide.
Susquehanna River Water	(85.88)	(70)
Peach Bottom (*a*)	92.27	76
Bangor Summit	511.23	495
Delta	435.37	419
Bryansville	241.36	225
Woodbine	294.21	278
Bridgeton	304.89	289
Bruce	331.50	315
Muddy Creek	366.86	351
High Rock	382.93	367
Laurel	411.62	395
Fenmore	434.64	418
Brogueville	478.19	462
Felton	536.46	520
Windsor	598.8	583
Springvale	734.4	718
Red Lion	912.31	896
Dallastown	657.00	641
Ore Valley	570.32	554
Enterprise	531.20	515
Smalls Mills	433.75	418
Springgarden	431.53	415
York.....CC,, IV CCVII	381.24	365

a There is a Peach Bottom R. R. in Lancaster Co., branching from the Philadelphia and Baltimore Central, at Oxford, (see table CCLII,) and intended to connect with this line of York Co. at Peach Bottom, on the Susquehanna River.

CCVII. Pennsylvania Railroad, Frederick Division.

Levels of the Frederick Division, Pa. R. R., were copied from a profile of the road, in the office of the Pa. R. R. at Philadelphia, by permission of Mr. W. H. Brown, Engineer for Maintenance of Way.

Datum: Mean tide at Baltimore.

STATIONS.	Mean Tide.	Ocean Level.
York (*a*).....IV, CC	365	
Codorus Creek	357	
Graybills	426	
Bairs	452	
Spring Forge	455	
Menges Mill	455	
Iron Bridge	496	
Jacobs Mill	504	
R. R. Crossing (*b*)	607	
Hanover	599	
Conewago Bridge	546	
Littlestown	619	
Bridge	623	

a Junction with Northern Central; with York Branch of Columbia R. R.; and with Peach Bottom.

b Hanover Junction and Gettysburg R. R. Crosses at grade.

STATIONS.	Mean Tide.	Ocean Level.	
State Line	540		
Piney Creek	505		
Galts	486		
Taneytown	493		
R. R. Crossing (*c*).....CCLV	426		
Ladiesburg	464		
New Midway	458		
Woodsborough	400		
Georgetown	290		
Ritters	301		
Harmony Grove	310		
Frederick	280 (?)		
B. & O. Junction (*d*).....CCLVI	375		

c Western Maryland R. R., but *not at grade.*
d Connection with Baltimore and Ohio R. R.

CCVIII. Cumberland Valley R. R.

Levels on the Cumberland Valley R. R., were furnished by Mr. J. B. Dougherty, Engineer of the road at Chambersburg.

Datum: Originally a point on the Penna. R. R. at Harrisburg, foot of Market street, 315 feet above high water at Philadelphia.

STATIONS.	High Tide.	Ocean Level.	
Harrisburg (*a*).....I, CC	315	322	
Susq. Bridge, (west end) (*b*).....	350	357	
Shirmanstown			
Mechanicsburg	429	436	
Dillsburg Junction (*c*).....CCIX	420	427	
Kingston			
Middlesex			
South Mountain Junction (*d*)....	451	458	
Carlisle	470	477	
Greason's			
Newville	526	533	
Oakville			
Shippensburg	647	654	
Summit (*e*)	776	783	
Scotland			
Mount Alto Junction (*f*)	707	714	
Chambersburg	611	618	
Marion			
South Pennsylvania Junction (*g*)	625	632	
Greencastle	578	585	
State Line			
Hagerstown	565	572	
Falling Waters			
Potomac Bridge	369	376	
Beddington			
Martinsburg (*h*) CCLVI	457	634	

a Junction with Penna. R. R., and with Northern Central R. R.
b Bridgeport. *c* Dillsburg Junction. *d* South Mountain R. R. Junction.
e Mount Alto R. R. Junction. *f* Southern Penna. R. R. Junction.
g Junction with Baltimore and Ohio R. R.

CCIX. Mechanicsburg and Dillsburg R. R.

Levels on the Mechanicsburg and Dillsburg R. R. were copied from notes in possession of Mr. J. B. Dougherty, Assistant Engineer on the Cumberland Valley R. R., at Chambersburg, Pa.

Datum: That of the Pa. R. R., high tide at Philada.

STATIONS.	High Tide.	Ocean Level.	
Mechanicsburg Junc. (*a*) CCVIII	420	427	
Dillsburg	536	542	

a With Cumberland Valley R. R. at Mechanicsburg, 8.5 miles west of Harrisburg.

CCIX bis. South Mountain R. R.

No levels of this road could be obtained. It runs south from Carlisle by Papertown, to Pinegrove Furnace, on Mountain Creek in the South Mountains.

STATIONS.			
Carlisle Junction (*a*) CCVIII			
Bonny Brook			
Craigh Head's			
Mount Holly Springs			
Upper (Paper) Mill			
Hunter's Run			
Henry Clay			
Laurel			
Pinegrove (Furnace)			

CCX. Mount Alto R. R.

Levels on the Mount Alto R. R., were furnished by Mr. George B. Wiestling, Engineer and Superintendent.

Datum is "Elevation of Rail at foot of Market street, Harrisburg, 315.2 above high tide in Schuylkill River at Philadelphia."

This road runs to Mount Alto Furnace at the west foot of the South Mountain.

STATIONS.	High Tide.	Ocean Level.	
C. V. R. R. Junction (*a*)	705	712	
Summit (*b*)	732	739	
Brookside (*c*)	700	707	
Woodstock (*d*)	708	715	
Chambersburg Turnpike (*e*)	740	747	
Reno Ore Bank	875	882	
Mount Alto (*f*)	961	968	

a Junction with Cumberland Valley R. R., near Chambersburg.
b Between C. V. R. R. and Conochocheague Creek.
c At crossing of Creek.
d At crossing of Creek.
e Chambersburg and Gettysburg Turnpike,
f Near the Furnace.

CCX bis. Southern Pennsylvania R. R.

No levels could be obtained.

STATIONS.		Ocean Level.
C. V. R. R. Junction (*a*) CCVIII		
Williamson		
Lehmaster's		
Mercersburg Junction		
Loudon		
Richmond		
Mercersburg terminus		

a One mile south of Marion, and seven miles south of Chambersburg.

CCXI. Summit Branch R. R.

Levels of the Summit Branch R. R., were furnished by Mr. W. E. Ray, Supt. of the R. R., and cannot be relied upon as being entirely correct; but it is the only record which could be found of the road.

This road is called also the Lyken's Valley R. R.

Datum: Mean tide at Baltimore.

STATIONS.	Mean Tide.	Ocean Level.
Millersburg (*a*)	395	
Elizabethville		
Cross Road	660	
Lykenstown	675	
Wiconisco		
Big Lick Colliery		
Williamstown (*b*)	1125	

a On the Susquehanna River, east side; junction with Northern Central Railroad.

b Summit Branch Colliery. Connection broken for several miles with the Railroad from Brookside, past Good Spring, to Tremont and Pottsville.

CCXII. Selinsgrove and N. B. R. R.

Elevations on the line of the Selinsgrove and North Branch R. R. and of the Mifflintown Branch, of the same, were copied from notes in possession of Mr. W. A. Meeker, at Selinsgrove, Pa.

Datum assumed at a point on the D. L. & W. R. R. at Northumberland.

The second column gives the correlative heights above mean tide (Ocean level?) at Baltimore.

NOTE. This R. R. has never been built. Only the preliminary line levels at the points named are given in the following table.

The line starts in Northumberland at the terminus of the Bloomsburg Division of the Delaware, Lackawanna & Western R. R., crosses the mouth of the West Branch Susquehanna, and keeps down the right bank of the Susquehanna River, to the mouth of the Juniata River (Table CCXII).

The other branch of the line strikes across country from Selinsgrove to the Juniata River at Mifflintown (Table CCXIII).

STATIONS.	Assumed Elevation.	Mean Tide.	Ocean Level.
Northumberland (*a*)..CLVCCXV	100	439	
River Road (*b*)	86.4	426	
Keensville	84.9	424	
Selinsgrove (*c*)	88.7	428	
Burns dwelling house	67.9	407	
Pa. Canal (*d*)	70.6	410	
B. M., No. 16 (*e*)	74.7	414	
Port Trevorton R. R. Track	75.9	415	
Herrold's Saw Mill	63.3	403	
B. M., No. 18 (*f*)	72.6	402	
Wentzels Station	66.3	406	
McKee's Half Falls	63.1	402	
Rines Store	60.2	400	
B. M., No. 21 (*g*)	60.6	400	
Mahontonga Creek (*h*)	38.2	378	
B. M., No. 23 (*i*)	61.5	401	
B. M., No. 24 (*j*)	54.9	385	
B. M., No. 25 (*k*)	50.9	390	
Liverpool (*l*)	57.3	397	
Blattenberger's Mill	34.8	374	
Blattenberger's Creek (*m*)	16.4	356	
B. M., No. 27 (*n*)	31.4	371	
Montgomery's Creek (*o*)	14.5	354	
Girty's Notch Hotel	26.2	366	
B. M., No. 28 (*p*)	19.1	358	
New Buffalo (*q*)	24.6	364	
Buffalo Creek (*r*)	8.5	348	
B. M., No. 31 (*s*)	18	357	
Pittsburg Turnpike Crossing	15.2	355	
B. M., No. 33 (*t*)	—1.8	338	
Juniata River	–11.6	328	
Juniata Canal (*u*)	18.4	358	
Pa. R. R. (*v*)	23.5	363	
B. M., No. 34 (*w*)..I	19.6	359	

a Intersection with D. L. & W. R. R., at Northumberland.

b Opposite Northumberland.

c Centre of Pine Street.

d Top of mason work abutment of aqueduct, 2½ miles below Selinsgrove, crossing Penns Creek.

e Spike driven in telegraph pole, just above Port Trevorton.

f Below Port Trevorton, near two dwelling houses, on root of apple tree, 300′ from canal.

g 1500′ south of Benneville Kramer's house, on root of wild cherry tree.

h Surface of water, ordinary stage.

i 900′ north of Hoover's hotel, on chestnut tree.

j 2000′ south of "Dry Saw Mill" Hotel, piece of horse shoe, driven in telegraph pole.

k 500′ south of McCormick's barn, on root of elm tree.

l Centre of Market street.

m Surface of water.

n 900′ north of stone hotel, on root of black walnut tree.

CCXIII. Mifflintown Branch S. & N. Br. R. R.

NOTE. See last table CCXII.

STATIONS.	Assumed Elevation.	Mean Tide.	Ocean Level.
B. M., No. 1 (*a*).....CCXII	101.2	441	
Kautz P. O. (*b*)	95.5	435	
Millers Mill.....	134.4	474	
Freeburg.....	157.2	497	
Apple's Brick House	205.8	545	
Road (*c*).....	263	602	
Cross Creek	286.5	626	
B. M., No. 13 (*d*).....	375	714	
Shelly's Saw Mill (*e*).....	451.4	791	
Shelly's Summit.....	453.2	793	
Richfield	412.6	752	
B. M., No. 14 (*f*).....	408.7	748	
Cherryhill School House (*g*)	366.8	706	
Evansdale Summit.....	399	738	
Haldeman's Store (*h*).....	377.4	717	
Bunkertown Church (*i*)	350.3	690	
Bunkertown	354.3	694	
Little Lost Creek (*j*).....	355.4	695	
McAlistersville.....	308.6	648	
Leonard s Barn.....	262.9	602	
Wilson's Mill.....	227.2	566	
Wilson's Store.....	219.5	559	
Main Road (*k*).....	224	563	
Banks Summit	270.6	610	
Happy Hollow School House (*l*)..	160.5	500	
Daniel Seiber's (*m*).....	137.3	477	
Terminus of Line (*n*).....I	109.2	449	

a Top of mile post No. 7, S. & L. R. R.
b Waters edge, ordinary low water, Middle Creek.
c Leading from Middleburg to Tremont.
d 1300′ west of Brick School House, root of white oak tree.
e Waters edge, head of Shelly's saw mill pond.
f Near rivulet.
g Public road crossing.
h Public road from Evansburg to Foutz Valley, opposite Haldeman's store.
i In public road, near Bunkertown Church.
j Surface of water.
k In main road, from McAlistersville to Mifflintown, one mile west of Oakland mills.
l Surface of water, creek or run, west of Happy Hollow school house.
m Surface of water in creek, at D. Seibers.
n Mifflintown, on large peg, with nail driven near corner of stable, at fence post.

o Surface of water.
p Point of rocks, foot of Girty's Mountain, spike driven in telegraph pole.
q Water in mill race.
r Surface of water.
s 700′ south of J. Steel's dwelling house, on root of black walnut tree.
t 600′ south of Pittsburgh turnpike crossing, on root of hickory tree, on river bank.
u On towing path, Juniata Canal.
v On cross tie, Pa. R. R., near Duncannon.
w On top of locust stump, at edge of embankment of Pa. R. R.

CCXIV. Shamokin Branch N. C. R. R.

The elevations on Shamokin Branch of the Northern Central R. R., were urnished by Mr. A. B. Starr, Assistant Engineer P. & E. R. R.
Datum: Mean tide, Baltimore.

STATIONS.	Above Tide.	Ocean Level.
Sunbury Junction (*a*).....CC	442	
Snydertown.....	497	
Shamokin.....	738	
Lancaster Branch (*b*)	831	
Mount Carmel.....	1054	
End of Road..... ...	1090	

a Junction with N. C. R. W., at Sunbury.
b Junction with Lancaster Branch.

CCXV. Philadelphia and Erie R. R.

The levels on the Philadelphia and Erie R. R. were copied from the notes in the office of the Company at Williamsport, Pa., by permission of Mr. A. B. Starr, Assistant Engineer. These levels were made subsequent to 1862. It is intended to re-level the road in 1876, for no reliance is placed on the levels in this Table by the Engineers of the road.
Datum: Mean Tide at Baltimore.

STATIONS.	Mean Tide.	Corrected Levels.
Sunbury (*a*).....CC	428.30	
D.H. & W.R.R. Junc. (*b*).CXVII	436.10	
Northumberland (*c*).....CLV	439.30	
Montandon (*d*).....XIII	446.60	
Catawissa R.R. Crossing (*e*)..LXV	454.50	
Milton.....	458.30	
Watsontown.....	465.62	
Dewart.....	470.40	
Catawissa R.R. Crossing (*f*) LXV	473.82	
Montgomery.....	474.10	
Muncy.....	502.75	
Catawissa R.R. Crossing (*g*)..LXV	514.42	
Williamsport.....	510.43	
W. & E. (N. C.) Railroad Junction (*h*).....CCXVII	516.02	
Newberry.....	513.20	
Linden.....	517.21	

a Junction of Shamokin Branch of the Northern Central R. R.
b Junction Danville, Hazleton and Wilkesbarre R. R.
c Junction of Delaware, L. & W. R. R.
d Junction of Lewisburg, Centre & Spruce Creek R. R.
e Crossing of Catawissa R. R. near Milton.
f Crossing Catawissa R. R. near Montgomery.
g Crossing Catawissa R. R. below Williamsport.
h Junction with Northern Central R. W. near Williamsport.

STATIONS.	Mean Tide.	Corrected Levels.	
Susquehanna	516.60		
Jersey Shore	*577.07		
Pine	554.11		
Wayne	554.34		
Lock Haven (*i*) XV	†538.91		
Queen's Run	565.05		
Farrandsville	564.63		
Ferney	576.44		
Glen Union	587		
Whetham	600.80		
Ritchie	614.34		
Hyner	626.30		
North Point	641.02		
Renova	653.90		
Westport	672.64		
Cook's Bun	691.43		
Keating	700.90		
Wistar	720.72		
Round Island	736.81		
Grove	754.40		
Sinnemahoning	775.71		
Bennett's Br. Extension (*j*) CCCII	795		
Driftwood	797.75		
Huntley	842.93		
Sterling	896.38		
Cameron	943.73		
B. N. Y. & P. R.R. (*k*) CCXVIX	1003.09	(1024)	
Emporium	1014.99		
West Creek	1091.75		
Beechwood	1225.66		
Rathbon	1299.18		
Hemlock	1446.05		
West Creek Summit	1677.64		
St. Mary's	1649.50		
Scahonda	1503.90		
Daguschahonda (*l*)	1461.95		
Shawmut (*m*)	1408.56		
Ridgway	1375.73		
Johnsonburg	1423.52		
Wilmarth	1428.80		
Wilcox	1508.52		
Dahoga	1586.75		
Clarion Summit	2007.90		
Kane	2002.83		
Wetmore	1792.63		
Ludlow	1591.55		
Roy Stone	1403.75		

* Probably 557.07. † 558.91 ? See next Table below. See also the 555 of Table XV.

i Junction with Bald Eagle Valley R. R.

j Junction with the Bennett's Branch Extension of Allegheny Valley R. R.

k Junction with the Buffalo, New York & Philadelphia R. R.

l Here the Daguchahonda R. R. joins. No levels got.

m Shawmut R. R. No levels got.

STATIONS.	Mean Tide.	Corrected Levels.
Sheffield	1325.70	
Tiona	1348.03	
Clarenden	1385.46	
Stoneham	1335.93	
Warren.....CCCVI	1182.60	
Oil Creek & A. V. R. R. Crossing.....CCCIV	1158.80	
Irvineton	1156.60	
Youngsville	1199.85	
Pittsfield	1233.31	
Garland	1297.47	
Spring Creek	1383.85	
Columbus	1389.18	
B.C.&P.R.R. Crossing (*l*) CCCIX	1429.20	
Corry	1419.58	
A.&G.W.R.R. Crossing (*m*) CCC	1415.92	(1439)‡
Lovell's	1362.90	
Concord	1373.80	
Union	1258.63	
Lebeuff	1207.20	
Waterford	1181.72	
Jackson's	1218.70	
Langdon's	1123.52	
Belle Valley	995.96	
L. S. & M. S. Railroad Crossing (*n*).....CCCLXXXIII	675.64	
Erie Depot.....CCCLXXXIV	(573)	
Lake Erie, Water	(565)	(573)‖

l Crossing of the Buffalo, Corry and Pittsburgh R. R.
m Crossing of the Atlantic & Great Western R. R.
n Junction with the Lake Shore and Michigan Central at Erie.
‡ Level by the N. Y. & E. R. R.
‖ Accepted level of Lake Erie.

NOTE.—In the following Table some levels according to a profile made by John F. Burgin, Civil and Topographical Engineer, in 1862, are compared with levels of the same points found in Table CCXV above.
Column 1 shows Mr. Burgin's figures.
Column 2 shows the office figures.

STATIONS.	Above Tide.	Above Tide.	Difference.
Sunbury	423	428	+ 5
Milton	451	458	+ 7
Williamsport	506	510	+ 4
Lock Haven (*a*)	552	539	+ 7
De Crano	716		
2d Fork Sinnamahoning	787	798 ?	+11
Emporium	1011	1015	+ 4
Foot of Maximum Grade	1330		

a The 539 must be an error for 559.

STATIONS.	Above Tide.	Above Tide.	Difference.
West Creek Summit	1682	1678	— 4
St. Mary's (*b*)	1628	1649	+21
Foot of Maximum Grade	1518		
Ridgway (*c*)	1387	1376	— 9
Johnsonburg	1429	1424	— 5
Wilcox	1501	1509	+ 8
Foot of Maximum Grade	1525		
Clarion Summit	2006		
Head of Two Mile Run	1914		
Foot of Maximum Grade	1456		
Sheffield	1324	1326	+ 2
Dutchman's Summit	1393		
Warren	1189	1183	— 6
Irvine	1162	1157	— 5
Youngsville	1203	1200	— 3
Pittsfield	1236	1233	— 3
Garland	1298	1297	— 1
Spring Creek Station	1381	1384	+ 3
Columbus	1388	1389	+ 1
Corry	1416	1420	+ 4
Logan's Summit	1429		
Lovell's	1363	1363	0
Concord	1372	1374	+ 2
Union	1259	1259	0
Le Boeuf	1205	1207	+ 2
Waterford	1181	1182	+ 1
Jackson	1218	1219	+ 1
Langdon's	1123	1124	+ 1
Belle Valley	994	996	+ 2
Erie Depot	573		
Lake Erie Surface (*d*)	565		

b Difference of 21 feet probably to be accounted for on the supposition that two different points are indicated, the gradients here being very steep.

c Head of the Clarion River, at the forks.

d The level of Lake Erie water was fixed by J. T. Gardner's Tables (U. S. Geol. and Geographical Survey of Colorado, for 1873, p. 635) "mean of observations from 1841 to 1857, 573.08;" adopted result at Cleveland, dependent upon repeated Erie Canal Levels and U. S. Coast Survey work.

CCXVI. Muncy Creek R. R.

The levels on the Muncy Creek R. R. were furnished by Mr. B. Morris Ellis, Treasurer.

Datum: Catawissa; (Reading) R. R. Mid tide at Philadelphia. Add 3 feet, for Ocean Level.

This R. R. line runs northeast, up Muncy creek to the top of the Allegheny or Great North Mountain table land of Sullivan County.

STATIONS.	Mean Tide.	Corrected Tide.
Hall's Station (*a*) LXV	410	510
*Hughesville (*b*).....	483	583
Picture Rock.....	551	651
Tivola.....	591	691
Muncy Bottoms.....	675	775
Sonestown.....	829	929
McNeal's Summit (*c*).....	1676	1776

a On Catawissa R. R. east bank of River.

b Mr. B. Morris Ellis, says, "This station is 80 feet higher than the Muncy Station (west side of river) on P. & E. R. R." called in Table CCXV, 502.75, and therefore, Hughesville is 582.75. Accordingly 100′ is added to Mr. Ellis' 483, and therefore to all other figures in the first column to make the second.

c This is the dividing ridge, between the Loyalsock and Muncy Creeks, which head within one-fourth mile of each other. It is known as McNeal's Summit, an engineer of that name having established a "bench" at this point many years since. It is two miles south of the town of Laporte (B. Morris Ellis).

Elevations of points in Sullivan County, Pa., furnished by Mr. B. Morris Ellis, of Hughesville, Pa.

In Cully township, in front of the hotel, at Long Pond, it is 2235′ above tide.

On the turnpike, one mile west of Long Pond, 2285′, the highest *known* point in Sullivan County.

At Lewis Lake, or Eagles Meare, it is 1726′.

CCXVII. Williamsport and Elmira R. R.

(NOW NORTHERN CENTRAL.)

Levels on this Northern Division of the Northern Central R. R. from Williamsport to Canandaigua, were copied from a profile in the office of the Company at Elmira. This road runs north up Lycoming creek.

Datum: Mean tide at Baltimore, Md.

STATIONS.	Mean Tide.	Ocean Level.
Williamsport (*a*).....CCXV	540	
Cogan Valley.....		
Crescent.....		
Trout Run.....		
Bodine's.....		
Ralston.....	860	
Roaring Branch.....		
Carpenter's.....	1200	
Canton.....	1250	
Minnequa.....	1230	
Alba.....		
West Granville.....		
Granville Summit.....	1393	

a Junction with Philadelphia and Erie R. R.

STATIONS.	Mean Tide.	Ocean Level.
Troy	1100	
Columbia Cross Roads		
Snedeker's		
Gillett's		
New York State Line		
Elmira (*b*).....CLXII	865	
Horse Heads		
Pine Valley		
Mill Port		
Croton		
Havana	400	
Watkin's		
Rock Stream		
Starkey		
Himrod's		
Milo		
Pennyan		
Benton		
Hall's		
Stanley (*c*)		
Hopewell		
Canandaigua (*d*)	1070	

b Crosses New York and Erie R. R.
c Junction with Ontario and Southern R. R.
d Connects with New York Central and H. R. R. and Canandaigua and Tonawanda R. R.

CCXVIII. Jersey Shore, Pine Creek, and Buffalo R. R.

Levels on the J. S., P. Cr., and Buffalo R. R. were furnished by Mr. John S. Ross, Auditor. Datum: "Atlantic Ocean." This road is not yet built.

STATIONS.	Ocean Level.
Williamsport, City limit (*a*) CCXV	502
Linden (Surface of Canal)	501
Larry's Creek (on Plank Road)	514
Jersey Shore (Main Street)	521
Pine Creek Crossing (Lentz)	532
" " (Ramsey's Bend)	558
Waterville (Surface Little Pine Cr)	587
Jersey Mills	626
Campbelltown	673
Pine Cr. Crossing (near Slate Run)	709
" " " Cedar "	760
Babb's Creek Road	833
Pine Cr. Crossing (ab. Marsh Cr.)	1106
Gaines' (Water, Pine Creek)	1219
Kilbourne's (Water, Pine Creek)	1274
Grade at Summit of Tunnel	2202
Coudersport	1634
Roulette	1510
Port Allegheny (*b*).....CCXIX	1454

a The Canal level at Williamsport, however is 509 according to Table CCIII.
b On Buffalo, N. Y. & Phila. R. R.—The difference between the Tables 1479—1454 = 25′ is unexplained.

CCXIX. Buffalo, New York and Philadelphia R. R.

Elevations on the B. N. Y. and P. R. R. were furnished by Mr. Geo. S. Gatchell, Engineer, who writes: "Calling Lake Erie 573′ above tide, *our* elevation at the crossing of the Erie Railway, at Olean, is 1435. Erie (R. R. levels) 1438, difference 3′. At Buffalo our elevation is 11′ above what we took to be surface of water in Lake Erie, but I do not think it is exactly right. We assumed surface of water in Lake Erie from surface of water in Buffalo Creek, about 3 miles from the Lake. Lake Erie, 573′; our depot, 11′ = 584; Erie Railway (levels) 588; difference 4′. You see the difference at Olean & Buffalo is very near the same. The Erie Railway here (at Olean), is on about the same elevation as our track."

STATIONS.	+Lake Erie	Above Tide	Erie R. R. Correction.
Emporium (*a*).....CCXV	448	1021	1024
Shippen.....	630	1203	1206
Keating (Summit).....	1305	1878	1881
Liberty.....	1070	1643	1646
Port Allegheny	906	1479	1482
Larabee's.....	905	1478	1481
Eldred.....	867	1440	1443
State Line.....	867	1440	1443
Portville.....	866	1439	1442
Olean (*b*).....CLXII	862	1435	1438
Hindsdale.....	880	1453	1456
Ischua.....	965	1538	1541
Franklinville.....	1017	1590	1593
Machias	1080	1653	1656
Yorkshire.....	882	1455	1458
Arcade.....	881	1454	1457
Protection.....	807	1380	1383
Holland.....	600	1173	1176
South Wales.....	414	987	991
Aurora.....	348	921	925
Jamieson.....	317	890	894
Elma.....	250	823	827
Spring Brook.....	180	753	757
Ebenezer.....	63	636	640
Buffalo (*c*).....	11	584	588*

a On the Philadelphia and Erie R. R. where the unreliable list of the P. & E. R. R. makes the elevation 1003.09.

b Crosses New York & Erie R. R. R.

c Uses the same depot with the N. Y. & E. R. R., Lake Shore & M. S. R. R.

———. *Daguschahonda R. R.*

CCXX. McKean and Buffalo R. R.

Elevations on the McKean and Buffalo R. R. were furnished by Mr. S. V. Godden, Superintendent.

Datum: Lake Erie. To which must be added 573′ to reduce to Ocean Level.

The first column gives heights above an originally assumed Lake level. The second column corrects these heights for true Lake level.

STATIONS.	Above Lake Erie.	Above Lake Erie.	Above Tide.	
Buff. N. Y. & P. R. R. (*a*) CCXIX	873.00	896.50	1469	
Larabee's	871.50	895	1468	
Frisbee	860.50	884	1457	
Farmer's Valley	871.50	895	1468	
Smethport	889.06	913	1486	
Crosby	936.30	960	1533	
Colegrove	938.80	962.30	1535	
Hamlin	953.00	976.50	1549	
Wernwag	1256.50	1280	1753	
Clermont (*b*)	1469.50	1493	2066	

a Junction with the Buffalo, New York and Philadelphia R. R. near Larabee's Station, on the Upper Alleghany River. *b* Bishop's Summit.

VI. SOUTHERN SERIES.

CCL. West Chester and Philadelphia R. R.

The levels of the West Chester and Philadelphia R. R., were copied from the profile, by permission of Mr. Thos. H. Hall, Treasurer of the Company.

Datum: Ordinary *low* water at Philadelphia. This is about the same as Ocean Level.

STATIONS.	Above Tide.	Ocean Level.	
Philad'a Depot, 31st & Chestnut st	14	14	
Woodland Street	57	57	
Angora	74.5	74.5	
Fernwood	90	90	
Darby Road	103	103	
Kelleyville	102	102	
Clifton	109	109	
Springhill	128	128	
Morton	121.5	121.5	
Swarthmore	125	125	
Wallingford	168	168	
Manchester	211.5	211.5	
Media	210	210	
Greenwood	218	218	
Glen Riddle	160	160	
Lenni	136	136	
West Chester Junction (*a*) CCLII	133	133	
Darlington	143	143	
Glen Mill	199	199	
Cheney	240	240	
Street Road	252	252	
Hemphill	318	318	
West Chester	406	406	

a With Philadelphia and Baltimore Central R. R.

CCLI. West Chester R. R.

Elevations of points on the West Chester Railroad, were copied from a profile made in 1831, in possession of Mr. Thos H. Hall, Treasurer, at the office of the Company, in Philadelphia. There is no location of the present stations on the profile, therefore the elevations in the following list, are given at the points where marked on the profile.

Datum: "Tide;" but a correction of 21 was needful; see note *b*; add 7 feet for Ocean level below P. R. R. datum.

STATIONS.	"Tide."	Corrected Tide.	Ocean Level.
West Chester			
Liberty Grove (*a*)	475.6	455	462
Goshen Street	474.6	454	461
Jones Hill	540	519	526
Ship Road	471	550	557
Steamboat Road	599.50	579	586
Summit	607.33	587	594
Malvern Junction P. R. R. (*b*)..I	560	539	546

a The starting point of the road in the *eastern* part of the town of West Chester.

b Junction with Pennsylvania R. R. at Malvern Station. The elevation of the Pa. R. R. at this point is + 539.258. The levels on West Chester Railroad have been reduced to correspond with Pa. R. R.

CCLII. Philadelphia and Baltimore Central R. R.

Levels on the Philadelphia and Baltimore Central Railroad, were copied from a profile furnished by Mr. H. Wood, Gen'l Supt.

Datum is said to be *mid tide* at Philadelphia = about Ocean level.

STATIONS.	Above Tide.	Ocean Level.
Lamokin Junction CCLIII		
Rockdale		
Lenni		
West Chester Junction (*a*)..CCLI	133	133
Chester Heights	234	234
Patterson		
Woodland	212	212
Concord	237	237
Brandywine Summit	273	273
Chadd's Ford	129	129
Fairville	255	255
Rosedale	312	312
Kennett Square	260	260
Toughkennamon	283	283
Avondale	227	227
West Grove	444	444
Penn Station	506	506
Elk View		
Lincoln University		
Oxford (*b*)		
Rising Sun		
Rowlandville		
Columbia & P. D. Junc. (*c*)CCLIV		

a With West Chester and Philada. R. R. *b* With Peach Bottom R. R.
c On the Susquehanna River above Port Deposit.

** *Peach Bottom R. R.*

STATIONS.			
Oxford Junction CCLII			
Hopewell			
Tweeddale			
Spruce Grove			
White Rock			
Kings Bridge			
Fairmount			
Fulton House.....			

** See CCVI.—Levels of this road wanting.

CCLIII. Philadelphia, Wilmington and Baltimore R. R.

Levels of the P. W. & B. R. R. were copied from the profile in the office of the Company at Philadelphia. Assumed level 94 feet too high.
Datum: Ordinary *low* water at Philadelphia = Ocean level.

STATIONS.	Profile.	Corrected Tide.	
Philadelphia.....			
Southwark	101.40	7.40	
Third Street	120.55	26.55	
Sixth Street.....	126.78	32.78	
Seventh Street	127.58	33.58	
Tenth Street.....	126.26	32.26	
Twelfth Street.	120.59	26.59	
Eighteenth Street	129.66	35.66	
Newport Street.....	137.53	43.53	
Greys Ferry Bridge.....	130.59	36.59	
Lazaretto	115.89	21.89	
Paschall			
Darby Street			
Sharon Hill			
Ridley Park.			
Chester Bridge (*a*)	118.33	24.33	
Lamokin Junc (*b*).....CCLII			
Thurlow	128.24	34.24	
Linwood.....	124.88	30.88	
Claymont	123.50	29.50	
Holly Oak	103.50	9.50	
Bellevue	108.07	14.07	
Wilmington LVI	101.11	7.11	
Delaware R. R. Junction			
Newport			
Staunton			

a Near Chester Station.
b Philadelphia and Baltimore Central R. R.

STATIONS.	Profile.	Assumed Elevation.	Corrected Tide.	
Newark	200.13	94	106.13	106
Iron Hill	216.70	94	122.70	123
Elkton	122.25	94	28.25	28
North East	137.75	94	43.75	44
Charlestown				
Perryville (*c*) CCLIV	115.48	94	21.48	21
Susquehanna (*d*)	110.34	94	16.34	16
Havre de Grace	110.12	94	16.12	16
Aberdeen	169.80	94	75.80	76
Perrymansville	136.39	94	42.39	42
Edgewood				
Magnolia				
Gunpowder Bridge	103.78	94	9.78	10
Chase's	114.40	94	20.40	20
Stemmer's Run				
Patapsco Neck	111.13	94	17.13	17
Bayview Junction (*e*)..CC	129.92	94	35.92	36
Baltimore Dep't(*f*)CCLVI	103.33	94	9.33	9

c Port Deposit Branch R. R.
d Susquehanna River, north-east side.
e Northern Central Railway Junction.
f Baltimore and Ohio R. R.

CCLIV. Columbia and Port Deposit R. R.

Elevations on the Columbia and Port Deposit R. R., were copied from a profile furnished by Mr. J. B. Hutchinson, Chief Engineer.

Datum: *Mean* tide at Port Deposit, nearly = Ocean level.

STATIONS.	A. M. T.	Ocean Level.
Perryville (*a*) CCLIII		(21)
Port Deposit	8	8
P. & B. C. R. R. Junc. (*b*) CCLII	35	35
Conomingo Creek	70	70
Ball Friar	77	77
Ark Haven	79	79
Peach Bottom (*c*)	98	98
Fishing Creek	108	108
Fights Eddy	118	118
McCalls Ferry	168	168
York Furnace	176	176
Shank's Ferry	182	182
Safe Harbor	197	197
Wislar's Run	228	228
Washington	231	231
Columbia (*d*)	240	240

a Philadelphia, Wilmington and Baltimore R. R.
b Junction with Baltimore Central R. R.
c Peach Bottom R. R. starts from the opposite side of the Susquehanna River. See table CCVI.
d The elevation is in the lower part of Columbia, and is about 4′ lower than where the elevation is given on Pa. R. R. "Elevation on Pa. R. R. track in front of passenger station is 244′."

CCLV. Western Maryland R. R.

Elevations of the W. M. R. R., were copied from profile furnished through the kindness of Gen. J. M. Hood, President and Gen'l Manager of the road.
Datum: *Mean* tide at Baltimore = ? Ocean level.

STATIONS.	Tide.	Ocean Level.
Baltimore, Canton Wharf	20	20
B. & P. R. R. Crossing (*a*)....CC	150	150
Oakland		
Arlington		
Mount Hope		
Howardville		
Pikesville		
Greenwood		
McDonough		
Junction		
Owing's Mills	480	480
Timber Grove		
Reisterstown	600	600
Glen Morris		
Finksburg		
Patapsco	360	360
Shamberger's		
Parrs Ridge	680	680
Tannery		
Westminster (*b*)	680	680
Avondale		
Smith's Switch		
New Windsor	440	440
Linwood		
Union Bridge	350	350
Middleburg		
Frederick Junction (*c*) ...CCVII		
Double Pipe Creek		
Monocacy River	280	280
Rocky Ridge	370	370
Loy's		
Graceham		
Mechanicstown	475	475
Sabillasville		
Blue Ridge Summit (*d*)	1373	1373
Waynesborough		
Smithsburg		
Chewsville		
Antietam Creek	460	460
Cumbl'nd Valley Junc.(*e*)CCVIII		
Hagerstown	520	520
Williamsport	305	305

a Baltimore and Potomac R. R. (or Northern Central) Crossing.
b Bachman's Valley R. R., no levels obtainable.
c Frederick Division of Penna. R. R. CCVII.
d Montery Springs Summit.
e Cumberland Valley R. R. Level in table CCVIII is feet.

CCLVI. Baltimore and Ohio R. R.

Levels on the B. & O. R. R., were copied from a profile and notes in the office of the Company at Baltimore, by permission of Mr. W. N. Bolling, Engineer.

Datum: The levels are based upon mid tide at Baltimore, and are according to the original survey of the road by Mr. B. H. Latrobe, Chief Engineer, many years ago.

It was impossible to get the levels at all the stations on the road.

STATIONS.	Mean Tide.	Ocean Level.
Baltimore (Camden Station).....	24	24
Mount Clair.....	66	66
Winan's Station (*a*) CC		
Washington Junction (*b*).....		
Ellicotts Mills...	139	139
Elysville.....		
Woodstock.....		
Marriottsville.....		
Sykesville.....		
Parr's Ridge.....	813	813
Gaither		
Woodbine.....		
Mount Airy		
Monrovia.....		
Ijamsville		
Hartman's		
Frederick City Junc. (*c*) ...CCIX		
Monocay River.....	262	262
Frederick City.....	280	280
Doub's		
Point of Rocks (*d*).....	221	221
Berlin		
Knoxville (*e*)		
Hagerstown Junction.....		
Sandy Hook.....		
Harpers Ferry (*f*).....	272	272
Duffield's		
Kearneysville.....		
Vanclieveville....		
Martinsburg.....		
Shepardstown Road	467	467
North Mountain.....	547	547
Cherry Run.....	398	398

a Baltimore and Potomac R. R. Crossing.

b Washington Branch B. & O. R. R. diverges from main line at this point.

c Frederick Branch B. & O. R. R.

d Metropolitan Branch B. & O. R. R. connects with main line. *No levels of this line.*

e Washington County Division B. & O. R. R. joins main line at this point. *No levels of this line.*

f Winchester, Potomac & Strassburg R. R. connects with B. & O. R. R. This is one of the R. R's of the State of Virginia.

STATIONS.	Mean Tide.	Ocean Level.
Sleepy Creek.....		
Hancock.....(about)	424	424
Sir John's Run.....	434	434
Great Cacapon.....		
Willett's Run		
Rockwell's Run.....		
Doe Gully Tunnel	545	545
Little Cacapon.....	562	562
South Branch Potomac River....		
Green Spring Run		
Patterson's Creek.....	568	568
Cumberland (*g*).....CCLIX	639	639
Brady's Mill.....		
Rawlings.....		
Black Oak Bottom		
New Creek		
Piedmont .....(about)	919	919
Bloomington.....	993	993
Frankville		
Swanton.....		
Altamont.....	2620	2620
Deer Park.....		
Oakland		
Huttons.....		
Cranberry Summit.....	2550	2550
Rodermer's Tunnel.....		
Rowlesburg		
Cheat River.....	1397	1397
Cassady Summit.....	1856	1856
Kingwood Tunnel	1820	1820
Tunnelton.....		
Newburg.....		
Independence		
Raccoon Run.....	1227	1227
Thornton.....		
Grafton (*h*)	985	985
Fetterman		
Valley Falls.....		
Texas.....		
Benton's Ferry.....		
Fairmount.....	888	888
Barnesville		
Barrackville.....		
Farmington.....		
Mannington		
Glover's Gap.....	1150	1150
Glover's Gap Tunnel	1146	1146
Burton.....		
Littleton.....		

g Pittsburgh and Connellsville Branch of B. & O. R. R. intersects main line here.

h Parkersburg Branch B. & O. R. R. diverges from main line at this point.

STATIONS.	Mean Tide.	Ocean Level.
Board Tree Tunnel	1104	1104
North Fork of Fish Creek	887	887
Bellton		
Welling Tunnel	1193	1193
Cameron	1049	1049
Easton's		
Roseby's Rock		
Moundsville (*i*)	661	661
McMechen's Cut		
Benwood South Bank of Wheeling Creek	648	648
Wheeling, High Water (*j*)	637	(663)

i Here the R. R. strikes the Ohio River bank and ascends hence to Bridgeport, opposite Wheeling; crosses by a bridge and continues west as Central Ohio Division of Baltimore and Ohio R. R.

j Wheeling.—Mr. J. T. Gardner, in his "Elevations of certain datum points," p. 655 of Hayden's Report of 1873, treats fully of the level of the Ohio River at Wheeling, in relation to the levels of the B. & O. R. R., and arrives at the "probable" conclusion that "the B. & O. R. R. results are too low," giving an improbable fall to the Ohio from Steubenville, exceeding 1 foot per mile, which is known to be its true rate of fall, from P. & S. R. R. and C. & P. R. R. surveys. High water at Wheeling is 637′ by B. & O. R. R. survey of 1832, and the "channel" is 588. This is about 30′ too low. Mr. Gardner makes Wheeling H. W. 1852 . . . . . about 663

CCLVII. Cumberland and Pennsylvania R. R.

Levels on the C. & P. R. R. were furnished by Mr. James A. Millholland, Vice-President of the Company, Cumberland, Md.

STATIONS.	Above Tide.		
Cumberland (*a*).....CCLVI	650		
Eckert Branch Junction (*b*)			
Mount Savage Junction (*c*)			
C. & P. Junction (*d*)			
Barrelville			
Mount Savage	1206		
Frostburg	1920		
Neff Run			
Lonacoming	1560		
Barton			
Piedmont (*e*)	928		

a Baltimore and Ohio R. R.—Level of "Cumberland" in B. & O. R. R., Table CCLVI is 639, which, however, is Mr. Latrobe's original level.

b No levels.

c Bridgeport & Bedford R. R.

d Connellsville & Pittsburgh Branch B. & O. R. R.

e Rejoins the Baltimore & Ohio R. R.

NOTE.—This road runs back of the mountain, west of the river, through the Cumberland Coal Basin.

CCLVIII. Cumberland Turnpike Road.

Levels on the Cumberland Turnpike Road were copied from a report made by Jonathan Knight, Chief Engineer of the Baltimore and Ohio R. R., October 5th, 1835. They were partly taken from a map and profile made by James Schriver, in 1824. Mr. Knight says, in his report, "The levels may be sufficiently accurate for such a road (turnpike), yet are not so exact as levelings taken for a canal or railroad."

Datum: Probably mean tide at Baltimore.

NAMES OF TOWNS, &c.		Above Tide.	
Cumberland	CCLVI	635	
Frostburg		1890	
Great Savage Mountain Summit		2657	
Savage River, 2 miles from its head		2376	
Little Savage Mountain Summit		2535	
Little Backbone Mountain Summit at (Beall's) Dividing Eastern and Western Waters		2372	
Meadow Mountain Summit (Alleghany Mtn.)		2654	
Castelman's River		2077	
Negro Mountain Summit		2826	
Keyser's Ridge Summit, a spur of Negro Mountain		2843	
Winding Ridge Summit		2534	
Smythfield at Youghiogheny River		1405	
Barren Hill Summit		2450	
Woodcock Hill or Briery Mountain		2500	
Laurel Hill or Most Western Mountain		2412	
Munroe at Western Base of Laurel Hill		1065	
Uniontown		952	
Cauley's Hill		1274	
Brownsville at Monongahela River		873	
Hillsborough		1750	
Washington		1406	
West Alexandria		1797	
Wheeling		748	

CCLIX. Pittsburgh and Connellsville R. R.

Levels on the P. & C. Branch of the B. & O. R. R. were copied from the profile in the office of the Company at Connelsville, Fayette County, Pa.

Datum: As noted on the profile is 200′ *below low water at Pittsburgh*, and 514′ *above mean tide;* therefore 514′ has been added to each elevation, as copied from the profile to get mean tide at Baltimore = ? ocean level.

STATIONS.		Assumed Elevation.	Mean Tide.	
Cumberland (*a*)	CCLVI	124	638	
Mt. Savage Jun. (*b*)(*c*)	IX. CCLVII.	170	684	

a With B. & O. R. R.
b Cumb. & Pa. R. R.
c Bedford & Bridgeport R. R.

STATIONS.	Assumed Elevation.	Mean Tide.
Ellerslie	216	730
Cook's Mills	270	784
Bridgeport	424	938
Fairhope	870.5	1385
Southampton	104.5	1564
Glencoe	1119	1633
Philson's	1347	1861
Sandpatch Tunnel	1712	2226
Summit	1772	2286
Myersdale (*d*) CCLX	1549	2063
Garrett (*e*) CCLXI	1433.5	1948
Pinegrove	1360	1874
Mineral Point (*f*) CCXII	1310.9	1825
Castleman	1142.6	1757
Pinkerton	1135	1649
Shoo-Fly Tunnel	1100	1614
Brook Tunnel	1044	1558
Ursina (*g*)		
Confluence	832	1346
Draketown Run	805	1319
Egypt	788	1302
Ohio Pyle	723	1237
Indian Creek	468	982
Sand Works	407	921
White Rock (*h*) CCLXIII	407	921
Connellsville (*i*) CCLXVI	380	849
Broad Ford (*j*) CCLYIV	358	872
Sedgwick	354	868
Dawson (*k*) CCLXV	350	864
Laurel Run	342	856
Oakdale	338	852
Layton	304	818
Barring's	290	804
Jacob's Creek	280	794
Smith's Mill		
Port Royal	278	792
Snyder's	274	788
West Newton	268	782
Sewickley (*l*) XXXI		(780)
Armstrong's	265	779
Robbin's	254	768
Coultersville	254	768
Alpsville	254	768
Osceola	254	768

d Salisbury & Baltimore R. R. Junction.
e Buffalo Valley R. R.
f Somerset & Mineral Point R. R.
g Coal R. R.
h Fayette and Uniontown Branch R. R.
i S. W. Pa. R. R.
j Mt. Pleasant Branch.
k Hickman Run Branch R. R.
l Youghiogheny R. R., Branch of Pa. R. R. difference of 1' in levels at Sewickley.

STATIONS.	Assumed Elevation.	Mean Tide.
Ellrod	254	768
Long Run	251	765
McKeesport	251	765
Riverton	251	765
Saltsburg	251	765
Port Perry Junction	251	765
Braddock's	255	769
City Farm	247	761
Salt Works	252	766
Brown's	243	757
Grove	270	784
Hazelwood	275	789
Frankstown	269	783
Laughlin	256	770
Copper Works	249	763
Soho	255	769
Birmingham Bridge	237	751
Pittsburgh.....I	237	751

CCLX. Salisbury R. R.

Levels on the Salisbury R. R. were furnished by Mr. R. I. Batzer, C. E.
Datum: Pittsburgh and Connellsville R. R. at Meyersdale.
This road runs south up Castleman's River, towards the Maryland line.

STATIONS.	Mean Tide.
Pitts. & Conn. R. R. Junction (*a*) CCLIX	2095
Meyersdale	2063
Coal Mines (*b*)	2067
Romain	2073
Keystone	2075
Livengood's Mill	2100
Salisbury	2131
Coal Mines (*c*)	2331

a Junction with Pittsburgh and Connellsville R. R. near Meyersdale, or Myer's Mills.
b Cumberland and Elklich Coal Mines.
c Salisbury and Baltimore Coal Mines.

CCLXI. Buffalo Valley R. R.

Elevations on the Buffalo Valley R. R. were furnished by Mr. S. Philson, President of the Company.
Datum: Pittsburgh and Connellsville R. R.
This road runs north into Somerset County.

STATIONS.	Mean Tide.
Garrett (*a*).....CCLIX	1947
Burkholder.....	1992
Beaghley's.....	2010
Bitner.....	2044
Pine Hill.....	2064
Hanger's.....	2073
Berlin.....	2176

CCLXII. Somerset R. R.

NOTE.—The records of this road were destroyed by fire. It runs north into Somerset County towards Johnstown.

CCLXIII. Fayette Branch, P. & C. R. R.

Levels on this Branch of the Pittsburgh and Connellsville R. R. were copied from a profile in the office of the Company at Connellsville, Pa., through the kindness of Mr. W. H. Taylor, Resident Engineer.

Datum: Mean tide at Baltimore, Md.

This road runs southwest along the west foot of Chestnut Ridge towards the Virginia State line.

STATIONS.	Mean Tide.
White Rock (*a*).....CCLIX	907
Fayette.....	924
Watt's.....	991
Dunbar.....	1011
Ferguson.....	1138
Mt. Braddock.....	1175
Lemont's.....	1084
Evans'.....	1009
Hoggsett's.....	978
Uniontown.....	981

a Junction with Pittsburgh & Connellsville R. R. just above Connellsville.

NOTE.—The other bridge (at Connellsville) carries the southwest Pennsylvania R. R., which also runs up Dunbar Creek to Uniontown.

CCLXIV. Mt. Pleasant Branch, P. & C. R. R.

Data obtained as the last mentioned.

This road runs northeast along the west foot of Chestnut Ridge.

STATIONS.	Mean Tide.		
Broad Ford (*a*).....CCLIX	873		
Morgan's.....	944		
Tinstman's.....	1076		
Valley Coal Mines.....	1035		
Fountain Mills.....	1040		
West Overton.....	1045		
Iron Bridge.....	1052		
Stauffer's.....	1057		
Mt. Pleasant.....	1086		
End of Road.....	1083		

a Junction with Pittsburgh and Connellsville R. R. at Broad Ford, 3.2 miles below Connellsville.

CCLXV. Hickman's Run Branch, P. & C. R. R.

Data as above.

This road, one mile long, runs north to Coke Banks.

STATIONS.	Above Tide.		
Dawson Junction (*a*).....CCLIX	872		
Terminus of Road.....	1006		

a Junction with Pittsburgh and Connellsville R. R. near Dawson.

CCLXVI. Southwest Pennsylvania Extension.

Levels on the Extension of Southwest Penna. R. R. were furnished by Mr. John C. Oliphant, Engineer.

Datum is *high tide* in Schuylkill River, at Philadelphia. Add 7′ for ocean level. For the surveys an artificial datum was assumed, as shown in column 1. Column 2 gives this corrected for high tide at Philadelphia. Column 3 corrected for ocean level.

The main road is given in the I series, Table XXX.

This road crosses the Youghiogheny at Connellsville, and keeps up Dunbar Creek over to Uniontown, parallel with the Fayette County Branch of the P. & C. R. R. See Table CCLXIII.

STATIONS.	Assumed Elevation.	Above Tide.	Ocean Level.
Connellsville (*a*).....CCLIX	159.5	908	915
Sub-grade, Pier No. 1.....	153.6	902	909
Ordinary Water in Youghiogheny River, at R. R. Bridge, S. W. Penna. R. R.....	118	866	873

a Crosses *above* P. & C. R. R. here on a Bridge.

STATIONS.	Assumed Elevation.	Above Tide.	Ocean Level.
New Haven	138	886	893
Wheelerville	144	892	899
Dunbar	246.4	995	1002
Ferguson	376.2	1125	1132
Mt. Braddock (*b*)	448	1196	1203
Lemont	274.8	1023	1030
Hoggsett's Mill	205.7	954	961
Uniontown (*c*)	234.2	983	990

b Deep Cut; original surface 485 + 748.5 = 1233.5
c Intersection of Main Street and Broadway.

CCLXVII. Youghiogheny Coal Mine Levels.

Elevations of *Coal openings* on the line of Youghiogheny R. R. furnished by Mr. I. F. Wolf, Engineer Penn Gas Coal Company.

Datum: That of the Pa. R. R.

Youghiogheny Mine, No. 1	720.40
" " " 2	776.40
" " " 4	800.40
Th. Moore's drift at Moore's station P. & C. R. R.	793.40
Markel's Drift at Junction of Yough. R. R	824.44

CCLXVIII. Westmoreland Levels.

Various datum points in Westmoreland County, Pennsylvania, from a survey made by Mr. F. Z. Shellenberg, Superintendent of the Westmoreland Coal Company, Irwin's Station, Penna. R. R.

Datum: That of the Pennsylvania R. R. (Add 7′ for Ocean Level.)

Long Run Presbyterian Church Bench Mark on Door Sill	+ 1150′
Circleville Intersection of Mount Pleasant Turnpike with Greensburg and Pittsburgh Turnpike	1223
Jacksonville. Turnpike east end of town	1152
South Side Mine Mouth Coal	898
Larimer's Coal Mine	961
Ray's Coal Bank; on farm of William Ray's heirs	1052
Robinson's Coal Bank; on farm of R. S. Robinson	989
Bigley's Mines; Mouth of Drain, entry from Armstrong's Osceola Works, P. & C. R. R., at head of Bigley's Main Entry	902
Coal Hollow: Youghiogheny Coal Hollow Coal Company's Mines, between Guffey's and Shaner's Station, P. & C. R. R. Coal	789
Armstrong's Coal, opposite Buena Vista (east)	813
Moore's Coal Mine	812
Suter's Station, P. & C. R. R. Coal	843
Westmoreland Coal Shaft (Coal?)	751
Foster Shaft (Penn Township). Coal	935
Penn Coal Mine, north side of Penn Station, Pa. R. R	927
Kifer's Coal Bank, east of Penn Station, north side of Pa. R. R.	1140
Smith's Coal Bank	1180
Loughner's Coal Bank	1102

Harrison City, two miles north of Manor Station, on Pa. R. R., on *bridge* over Brushy Run 967
Cross Roads, two miles west of Harrison City 1185
Salem: *Intersection* of Freeport and Saltzburg Roads, northeast of Salem. 1231
Salem: Burnt Cabin *Summit*, between Allegheny and Monongahela Waters, between Beaver Run and Turtle Creek, one-half mile northeast of Salem. 1200
Salem Cross Roads (Delmont P. O.). 1255
Salem: Coal at Salem Cross Roads. 1272
Bouquet Village *Road*, opposite Grist Mill 1102
Bouquet Coal 1104
William Duff's Steam Grist Mill, *surface of water* just below Mill. . . 950
King's Bank, Coal at Burnt Cabin Summit. 1203
McQuade's Coal Bank on road leading from Salem Cross Roads to Freeport 1189
John Cochran's Coal Bank. 1132
Thorn Run: *Water* in Run at road crossing Jas. Cochran's farm. . . . 1080
Turtle Creek: *Water* in Creek at northern turnpike crossing, on Waugaman's farm 1051
Turtle Creek: Northern *turnpike* crossing, at Long's. 995
Turtle Creek: *Water* in Creek at Remaly's Mill. 950
Walton's *Summit*, between waters of Turtle Creek and Brushy Run . 1194
Longacre's *Summit* 1187
Brinker's *Summit* 1202
Fink's Run: *Water* at junction with Brushy Run, four miles north of Manor Station, Pa. R. R 1000

CCLXIX. Pittsburgh, Virginia and Charleston R. R.

Levels on the P. V. & C. R. R. were copied from the profile in the office of the company at Pittsburgh, by permission of I. M. Byers, Esq., Superintendent.

Datum:

This road ascends the west bank of the Monongahela River from Pittsburgh to the Virginia State Line, and is in process of completion above Monongahela City. It crosses the river from Pittsburgh to Birmingham on a high bridge.

STATIONS.	Above Tide.	Ocean Level.	
Pittsburgh (*a*).....CCCLII	750		
12th Street, Birmingham.....	786		
18th " "	779		
22nd " "	770		
30th " "	745		
Beck's Run.....	750		
Bird's Run.....	749		
Street's Run.....	745		
West's Run.....	740		
Homestead.....	745		
Patterson's Run.....	742		
Opposite Braddock's.....	730		
Thompson's	749		
Opposite McKeesport.....	725		
Curry's Run (*b*)	734		

a Junction with the Pittsburgh, Cincinnati and St. Louis R. R.
b On bridge.

STATIONS.	Above Tide.	Ocean Level.
Camden	738	
Rock Run	731	
Pine Run	739	
Peter's Creek	735	
Wylie's	743	
Elizabeth	731	
Walton's	741	
Hodgen's Coal Road	735	
Coal Bluff Road	735	
Houston's Run	740	
Buffalo Coal Works	748	
Mingo Creek	740	
Dry Run	735	
Monongahela City	737	
Pigeon Creek (*c*)	735	
Johnson's Coal Road	750	
Pike Run	719	
West Brownsville (*d*)	758	

c Surface of water at ordinary stage 709.
d In Street in front of Hotel.

VII. ALLEGHENY SERIES.

CCC. Pittsburgh City Levels.

Elevations at different points in the City of Pittsburgh, Pa., were furnished by Mr. William Martin, Assistant Engineer.

Datum: *Low water in the Allegheny River* at the Suspension Bridge, which according to Mr. Jas. T. Gardner's determination, is 699.20′ above the Mean Surface of the Atlantic Ocean. See page 655, Vol. I, Hayden's Geological Survey Report of 1873.

Elevation of Points in City of Pittsburgh, Pa.

BENCH MARKS.	City Datum.	Ocean Level.
On Window-sill of Monongahela Incline Plane, Check House..	407.075	1106.275
On Belt-course of Union Depot, Main Entrance	47.203	746.403
On East end Door-sill of Point Breeze Hotel at Intersection of Penn and Fifth Avenue...	273.814	973.014
On Belt-course of Munshall's Distillery, corner Penn Avenue and Water Street	28.198	727.398
On Door-sill of Post Office	51.554	750.754
On Embankment of *Lower* (old) Reservoir on Bedford Avenue	165.854	865.044
On Embankment of *Upper* (old) Reservoir, Bedford Avenue..	401.674	1100.874

BENCH MARKS.	City Datum.	Ocean Level.
On Flow Line of Highland Avenue (new) Reservoir.....	365	1064.20
On Flow Line of Herron Hill (new) Reservoir.....	560	1259.20
On Flow Line of Brilliant Hill (new) Reservoir.....	235	934.20

CCCI. Allegheny Valley R. R.

Levels on the Allegheny Valley R. R., from Kittaning to Oil City, were copied from notes in possession of Mr. Wainwright, Assistant Engineer, Engineer's Office, Allegheny Valley R. R., Pittsburgh, Pa.

This portion of the road was leveled during the summer of 1875. The elevation at Kittaning was assumed to be 500′ above tide. The difference between the true elevation and the elevation assumed at the Red Bank intersection of the Bennett's Branch R. R. with the main line, was made to be 284′. This must be incorrect.

Great difficulty has been experienced in connecting the levels of this road with those of others in Northwestern Pennsylvania, and no reliance can be placed upon their exactness. They are evidently *too low*, and the error seems to be in the 284′ feet difference; and therefore in the Bennett's Branch Extension Table, CCCII.

For instance, the level at Parker's City is, by this Allegheny Valley R. R. Table, 579.2 + 284 = 863′; whereas, Mr. Lucas makes it 909′, or 46 feet higher. See Section in Carll's Report of Progress, 1874.

Again, at Franklin this Table gives 678.5 + 284 = 963′; whereas, Lake Shore and Michigan Southern (Franklin Division) Table CCCLXII makes it 444.06 (+ Lake Erie) + 573 = 1017′, or 54 feet higher.

Again, at Oil City this Table gives 983′; whereas Oil Creek and Allegheny Valley R. R. (CCCIV) gives 995′, or 12′ higher. And the same in CCCLXXXVII by the Franklin Branch of Atlantic and Great Western.

The levels of points from Pittsburgh up to Kittaning could not be obtained by any efforts. There seem to be no records, profiles or notes of the levels of this part of the line. Pittsburgh is 745′ by Table I; Gardner makes it 746′, and so does Pittsburgh, Fort Wayne and Chicago R. R., Table CCLXXIII.

STATIONS.	Assumed	Tide.	Ocean Level.
Pittsburgh.....			(745)
Sharpsburgh.....			
Hulton.....			
Logan's Ferry.....			
Parnassus.....			
Tarentum.....			
Chartiers.....			
Soda Works.....			
West Penn Junction (*a*) XXVI.....			(778)
White Rock.....			

a With West Penn. R. R. east to Philadelphia.

STATIONS.	Assumed	Tide.	Ocean Level.
Kelly's.....			
Logansport.....			
Rosston.....			
Kittaning.....	500	784	791
Cowanshannock.....	498.8	783	790
Pine Creek.....	502.2	786	793
Templeton.....	513.9	798	805
Mahoning.....	514.4	799	806
Reimerton.....	526.8	812	819
Red Bank Junc. (*b*)CCCII	540.9	825	832
Phillipsburg.....	545.3	829	836
Brady's Bend.....	546.4	831	838
Catfish.....	548.5	833	840
Sarah Furnace.....	551.5	836	843
Hillsville.....	555.3	839	846
Monterey.....	564.7	849	856
Parker City (*c*)...CCCIII	579.2	863	870
Foxburg.....	586	870	877
Emlinton.....	595.2	879	886
Dotterer's.....	604.9	889	896
Black's.....	612.6	897	904
Rockland.....	616.6	901	908
St. George's.....	624.9	909	916
Scrub Grass.....	637.7	922	929
Brandon's.....	651.4	936	943
Foster.....	659.8	944	951
East Sandy.....	665.4	950	957
Cochran.....	672.5	957	964
Franklin(*d*) } CCCLXV / CCCLXII	678.5	963	970
† Oil City (*e*)....CCCIV	699.2	983	990

b Junction of Bennett's Branch R. R. Elevation according to profile of Bennett's Branch Ext. of Allegheny Valley R. R. + 824.70, which gives the above mentioned difference of 284', used for reducing the other levels to tide This however depends on the Phila. & Erie R. R. levels, Table , which are as unreliable as those of the Allegheny Valley R. R. The connection between Harrisburg and Pittsburgh, round by the West Branch Susquehanna River, is divisible into three sections, the middle one (Bennett's Branch Extension R.R.) alone being reliable.

c Junction with Parker and Karn's City R. R.

d Junction with Atlantic and Great Western R. R., and with Lake Shore and Michigan Southern (Franklin Division) R. R.

e South Oil City, river rail, main track, opposite lower end of platform of depot. Junction with Oil City and Allegheny Valley R. R.

NOTE.--Seven feet has been added to the second column in the above Table to make the third column agree with levels in Table CCCII.

CCCII. Bennett's Branch Extension R. R.

The levels on the Bennett's Branch Extension, A. V. R. R., were copied from the profile in the office of the A. V. R. R. at Pittsburgh, Pa., through kindness of Mr. H. Blackstone, Chief Engineer.

Datum: Tide water at Philadelphia.

This datum, however,is dependent upon the level of the eastern terminus or Driftwood Junction with the Phil. & Erie R. R. But this is known to be too low, and therefore, the levels of the whole line are too low, and carry down with them those of the Allegheny Valley Main Line, as stated in notes, to Table CCCI.

Mr. Burgin's original level on the P. & E. R. R. at Driftwood was 788'. This Mr. Wilson took for his datum level in the surveys of the Bennett's Branch Extension R. R. across to the Allegheny Valley R. R. Mr. Wilson's levels are given in column 1.

On the profile of the P. & E. R. R. used in Table CCXVI, the level of the point of junction is called 795 (7 feet higher). Column 2 makes this first correction, which helps to lift the Allegheny Valley levels a little, but not near enough.

Column 3 is left blank for a future correction, when the levels of the P. & E. R. R. are lifted, as they must be; for, although they start about right at Sunbury, they are already about 20 feet too low at Williamsport by the Catawissa R. R. (LXV), and by the Northern Central R. R. (CC) lists of levels; and feet too low at Lock Haven by the Pennsylvania R. R. (XV) branch lists. At Emporium also they are 18 feet lower than the Buffalo, N. Y. & Phil. Railroad (CCXIX).

But even this 20 feet added to the previous 7′ = 27′ will not suffice to lift the west end of this Bennett's Br. Ext. R. R. high enough to cancel the difference at Franklin and Oil City. It is probable, however, that the whole residual error lies on the Allegheny Valley R. R. line.

STATIONS.	Above Tide.	Above Tide.	Corrected Tide.	Ocean Level.
Driftwood Junction (*a*) CCXVI	788	795		
Mix Run	848	855		
Miller's	880	887		
Dent's Run	898	905		
Enz	938	945		
Grant	949	956		
Mount Pleasant	973	980		
Devil's Elbow	993	1000		
Benezette	1014	1021		
Meadic's Run (*b*)	1073	1080		
Caledonia Tunnel (*c*)	1122	1129		
Slabtown Dam	1163	1170		
Hebner's Run	1245	1252		
Clear Run	1385	1392		
Slab Run	1381	1388		
Fall's Creek	1381	1388		
Crooked Run	1378	1385		
Evergreen	1374	1381		
Maghee's	1361	1368		
Panther's Run (*d*)	1362	1369		
Reynoldsville	1351	1358		
Prior Run (*e*)	1342	1349		
Prindible's	1335	1342		

a With P. & E. R. R. near Driftwood. "795" on P. & E. profile.

b Bench mark on Bridge; West abutment, top of Cap-stone, N. E. corner.

c 250′ east of Tunnel.

d Cap-stone of east Abutment.

e Cap-stone of east Abutment.

STATIONS.	Above Tide.	Above Tide.	Corrected Tide.	Ocean Level.
McAnnutty Run (*f*)....	1335	1342		
Camp Run.....	1317	1324		
Fuller's Mill.....	1301	1308		
Wolf Run.....	1295	1302		
Cable Run.....	1285	1292		
Iowa Mill.....	1273	1280		
Gooseneck.....	1256	1263		
Bell's Mill.....	1340	1347		
Garrison's Mill.....	1235	1242		
Brookville.....	1209	1216		
Nicholson's Mill.....	1199	1206		
Corder's Run.....	1200	1207		
Puckerty Point.....	1189	1196		
Rattlesnake Run.....	1183	1190		
Baxter's Mill.....	1181	1188		
Heathville.....	1137	1144		
Motter's Run.....	1124	1231		
Bear Tree Run.....	1107	1114		
Maysville.....	1082	1089		
Pine Run.....	1075	1082		
Millville.....	1067	1074		
Indiantown Run.....	1063	1070		
Middle Run.....	1060	1067		
New Bethlehem.....	1054	1061		
Anthony's Neck.....	1025	1032		
Leatherwood.....	1001	1008		
Rock Run.....	940	947		
Buck Lick Run.....	913	920		
Lawsonham (*g*).....	893	900		
Fiddler's Run.....	889	896		
Red Bank Jun. (*h*) CCCI	825	832		
Sligo Branch of A. V. R. R.				
Lawsonham (*i*)...CCCII	891	898		
Stop's Run.....	913	920		
Fiddler's Run (*j*).....	966	973		
9000 feet (*k*).....	1043	1050		
14,000 feet.....	1141	1148		
15,000 feet.....	1161	1168		
17,000 feet.....	1202	1209		
23,000 feet.....	1325	1332		
Benn's Summit.....	1368	1375		
29,000 feet.....	1305	1312		
Cherry Run.....	1198	1205		

f Cap-stone of west Abutment.
g Sligo Branch R. R.
h With Allegheny Valley R. R.
i Junction.
j First crossing; centre of Trestle.
k From the Junction.

STATIONS.	Above Tide.	Above Tide.	Corrected Tide.	Ocean Level.
38,000 feet	1218	1225		
Sligo Summit	1300	1307		
Iron Ore Bank	1228	1235		
52,000 feet	1150	1157		
Little Licking Creek	1122	1129		
Big Licking Breek	1102	1109		
Sligo (*l*)	1090	1097		
End of Road	1085	1092		

Boston Branch of A. V. R. R.

Junction (*m*).....CCCII	1049	1056		
Bridge	1050	1057		
2,000 feet	1075	1082		
3,000 feet	1097	1104		
4,000 feet	1118	1125		
5,000 feet	1138	1145		
6,000 feet	1161	1168		

l Sligo Furnace is served by this road.

m There are no stations marked on the profile of this branch. The levels are given at thousand feet from the point of divergence from the main road.

CCCIII. Parker and Karns City R. R.

Levels of the Parker and Karns City R. R. were taken from notes in possession of Mr. Wm. M. Kipp, Engineer at Parker City. The datum of the preliminary survey was an assumed level 100 feet below the top of the west abutment of the iron bridge then building. This datum (as shown by subsequent surveys in locating the line) is 103.99′ below the top of the free-stone base of the toll house. The bridge rises 8′ going east, and there is a further rise from the end of the bridge to the A. V. R. R. depot of 1.98′, as ascertained by Mr. J. F. Carll, which will make the datum of P. & K. C. R. R. below the A. V. R. R. depot 103.99 + 8 + 1.98 = 113.97′. Elevation A. V. R. R. depot, Parker City 863 — 114 = 749 = datum which added to the elevations as copied from notes should bring levels to tide.

STATIONS.	Above Tide.	Above Tide.	Ocean Level.	
Parker Junc. (*a*)..CCCI		863	870	
Stone House	315	1064	1071	
Martinsburg	330	1079	1086	
Argyle	386.80	1136	1143	
Petrolia	401	1150	1157	
Central Point	410	1159	1166	
Karns City	430.33	1179	1186	

a With Allegheny Valley R. R.

NOTE.—Seven feet has been added to the second column in the above Table to make the third column agree with Tables CCCI and CCCII.

CCCIV. Oil Creek and Allegheny River R. R.

Levels on the Oil Creek and Allegheny River R. R. were copied from the profile in the office of the Company, at Oil City, by permission of C. J. Hepburn, Esq., Superintendent.

Datum: P. & E. R. R.

STATIONS.	Above Tide.	Ocean Level.
Irvineton (*a*).....CCXV	1158	
Dunn's Eddy.....	1144	
Penna. House.....	1140	
Thompson's.....	1130	
Cobham.....	1121	
Magee.....	1118	
Tidioute	1099	
Trunkeyville.....	1085	
Hickory.....	1078	
Dawson.....	1063	
Jamison.....	1060	
Tionesta.....	1047	
Hunter.....	1048	
Stewart.....	1034	
President.....	1035	
Eagle Rock.....	1033	
Henry's Bend	1022	
Oleopolis	1019	
Walnut Bend.....	1010	
Rockwood.	1003	
Imperial.....	995	
Oil City.....CCCLXVII	995	
McClintock.....	1045	
Rouseville	1026	
Rynd Farm.....	1030	
Tarr Farm.....	1049	
Columbia.....	1054	
Petroleum Centre.....	1076	
Boyd Farm.....	1073	
Pioneer	1086	
Shaffer	1120	
Miller's Farm.....	1118	
Titusville.....CCCVIII	1181	
Hydetown.....	1239	
Bridge (*b*).....	1241	
Gray's Mills (*c*).....CCCVII	1266	
Meyer's Switch	1230	
Tryonville.....	1305	
Centreville.	1284	
Glynden.....	1335	
Spartansburg.....	1444	
Summit.....	1634	
Stewart's Switch.....	1460	
A. & G. W. R. R. Crossing CCCLXV	1433	
Corry (*d*).....CCXV	1420	

a Junction with P. & E. R. R.
b Near Hydetown.
c Union and Titusville R. R. Junction
d Junction with P. & E. R. R.

CCCV. Pithole Valley R. R.

Levels on the Pithole Valley R. R. were furnished by Mr. Aug. Mordecai, Assistant Engineer A. & G. W. R. R. at Meadville, Pa.

STATIONS.	Above Oleopolis	+ Lake Erie	Ocean Level.
Oleopolis.....CCCIV	0	446	1019
Wood's Mills.....			
Prather.....	232	678	1251
Pit hole City.....	290	736	1309
Pleasantville	615	1061	1634
Enterprise.....	242	688	1261
Titusville.....CCCVI	162	608	1181

CCCVI. Dunkirk, Allegheny Valley and Pittsburgh R. R.

Levels on the Dunkirk, Allegheny Valley and Pittsburgh R. R., were copied from a list furnished by Mr. Henry E. Wrigley, C. E., who obtained the levels from the Engineer in charge of the road.

Datum: Lake Erie.

STATIONS.	+ Lake Erie	Ocean Level.
Titusville.....CCCIV	608	1181
East Titusville.....		
Pleasant Valley.....	755	1328
Grand Valley.....		
Star	785	1358
Newton.....	825	1398
Summit.....	878	1451
Garland.....	695	1268
Pittsfield.....	648	1221
Youngsville	611	1184
Irvineton.....	575	1148
Gravel Pit.....	595	1168
Jackson	603	1176
Warren.....	620	1193
North Warren.....	643	1216
Russelburg	660	1233
Ackley's	663	1236
Fentonville (*a*).....	670	1243
Frewsburg.....	688	1261
A. & G. W. R. R. Crossing CCCLXV	689	1262
Falconer.....	685	1258
Ross Mill.....	689	1262
Vermont.....	722	1295
Sinclairville.....	757	1330

a State Line of Pennsylvania and New York.

b Surface of water outlet of Chatauqua Lake 675 + Lake Erie 573 = 1248′ Ocean Level.

STATIONS.	+ Lake Erie	Ocean Level.
Moons	730	1303
Cassadago (*c*)	736	1309
Skidmore	744	1317
Norton's	425	998
Laona	239	810
Fredonia	192	765
Dunkirk (*d*)..CCCLXIII, CLXII	25	598

c Surface of water 732 + Lake Erie 573 = 1305′ Ocean Level.
d On the list from which the above levels were copied, no elevation was noted at Dunkirk, but as the D. A. V. & P. R. R. and the L. S. & M. S. R. R. use the same depot, the tracks being on the same level, and the elevation as given on profile of L. S. & M. S. R. R. taken as correct, it is therefore adopted as the elevation, at the terminus of this road.

CCCVII. Union and Titusville R. R.

Levels on the Union and Titusville R. R. were furnished through the courtesy of Mr. C. J. Hepburn, Supt. Oil Creek and Allegheny River R. R.
Datum: P. & E. R. R.

STATIONS.	Tide.	Ocean Level.
O.C.& A.R.R.R.Junc.(*a*) .CCCIV	1266	
Hydetown	1239	
Myer's Switch	1230	
Tryonville	1305	
Noble	1285	
Riceville	1356	
Lincolnville	1369	
Lakeville	1399	
Bloomfield	1396	
Union (*b*).....CCXV	1257	

a Junction with Oil Creek and Allegheny River R. R. at Titusville.
b Junction with Phila. and Erie R. R.

CCCVIII. Pennsylvania and Petroleum R. R.

Levels on the Pennsylvania and Petroleum R. R. were furnished by Mr. Aug. Mordecai, Asst. Eng. A. & G. W. R. R., Meadville, Pa.
Datum: Lake Erie.

STATIONS.	+ Lake Erie	Ocean Level.
Titusville.....CCCIV; CCCV	608	1181
Newton's Mills	685	1258
Athens Mills	693	1266
Little Cooley,	630	1203
Teeple Town	631	1204
Cambridge	585	1158
Edinboro	639	1212
Summit	705	1278
McKean's Corner	480	1053
Erie.....CCCLXIV		

NOTE.—The above levels are from the preliminary survey. The road is not yet built, but the proposed line is from Titusville to Erie.

CCCIX. (a) Buffalo, Corry and Pittsburgh R. R.

Levels on the Buffalo, Corry and Pittsburgh R. R. were obtained in Oil City, through kindness of Mr. C. I. Hepburn, Supt. O. C. & A. R. R. R.

STATIONS.	Above Tide.
Corry Junction..CCXV, CCCIV, CCCLXV	1423
Childs	1474
State Line	1417
Clymer	1146
Panama	1545
Sherman	1568
Summerdale	1629
Mayville	1300
Prospect	1221
Brockton (*b*).....CCCLXIII	672

a The levels on this road are supposed to be correct, and may be entirely so, but the profile from which the elevations were copied is indefinite as to the exact location of the stations.

b Junction with L. S. & M. S. R. R. Elevation on L. S. & M. S. R. R. at this point is 724′ above Mean Surface of Atlantic Ocean.

VIII. OHIO LINE SERIES.

CCCL. Pittsburgh, Cincinnati and St. Louis R. R.

Levels of the Pittsburgh, Cincinnati & St. Louis Railroad, were copied from profile in the office of the Company at Pittsburgh, Pa. The profile was furnished by Mr. S. M. Felton, Jr., Gen'l Supt.

Datum: Pennsylvania R. R. levels? Add 7′ for Ocean level.

STATIONS.	Mean Tide.	Ocean Level.
Pittsburgh (*a*).....I	(738)	(745)
Birmingham (*b*)	760	767
Jones' Ferry	75 7	764
Temperanceville	762	769
Sheridan	864	871
Cork Run	874	881
Ingram	880	887
Broadhead	872	879
Cemetery Crossing	867	874
Bridge, No. 3	824	831
Bridge, No. 4	787	794
Bridge, No. 5	775	782
Mansfield (*c*).....CCCLI	775	782
Walker's Mill	820	827
Oakdale	908	915
Noblestown	923	930
Willow Grove	988	995

STATIONS.	Mean Tide.	Ocean Level.
McDonald's	991	998
Primrose	1023	1030
Bulger	1146	1153
Bridge, No. 17	1222	1229
Burgettstown	1001	1008
Dinsmore	1082	1089
Bridge, No. 19	875	882
Paris Road	858	865
Bridge, No. 22	829	836
Collier's (*d*)	826	833
Holliday Cove		
Edgington (*e*)		
Steubenville (*f*) CCCLV		

a Pittsburgh Union Depot (746′, Gardner.)
b South side of Ohio River.
c Junction with Chartier's R. R.
d In Virginia.
e East side of Ohio River.
f West side of Ohio River and junction with Cleveland and Pittsburgh River Division R. R.

The levels of this road through Ohio are given on page 670, Vol. 1, Ohio Gelogical Survey, 1873; beginning with Steubenville, Washington Street = 155′.

CCCLI. Chartiers R. R.

Elevations on the Chartier's Branch R. R., were furnished by Mr. N. I. Becker, Chief Engineer, P. C. & St. L. Railway, Columbus, Ohio.

Add 7′ to reduce to Ocean level, and substract 1′ for the discrepancy at Mansfield, = 6′.

STATIONS.	Mean Tide.	Ocean Level.
Mansfield (*a*) CCCL	776	782
Leasdale	802	808
Woodville	807	813
Bridgeville	825	831
Boyce's	868	874
Hill's	873	879
Greer's	896	902
Van Emmau's	925	931
Cannonsburg	936	942
Houston's	952	958
Ewing's Mills	981	987
Cook's	1006	1012
Washington	1049	1055

a Junction with Pittsburgh, Cincinnati and St. Louis R. R. In table CCCLXXII 775′.

CCCLII. Hempfield R. R.

Elevations on the Hempfield Railway, were furnished by Mr. W. N. Bolling, Engineer B. & O. R. R.

Datum: Mean tide at Baltimore, Md., equal Ocean level. (No connection can be made at Washington between the Hempfield and Chartier's R. R. lines.)

STATIONS.	Mean Tide.	Ocean Level.	
Washington (*a*)..... CCCLI	(1049)	(1055)	
Thompson's Mills.....	699	699	
Chartier.....			
Taylorsville	1008	1008	
Claysville	683 (?)	683(?)	
Vienna.....			
West Alexandria.....	1099	1099	
Valley Grove.....			
Point Mills.....	896	896	
Roney's Point			
Triadelphia.....	734	734	
Elm Grove.....	683	683	
Carbon			
Mt. De Chantel.....	674	674	
Wheeling (*b*).....	644	644	

a Continuation of the Chartier's R. R.
b North and Water Streets 644′. Market Place 662′.

CCCLIII. Pittsburgh, Fort Wayne and Chicago R. R.

Levels of Pittsburgh, Fort Wayne and Chicago R. R., were copied from the profile (in the office at Pittsburgh), furnished through the kindness of Mr. F. S. Slataper, Chief Engineer.

Datum: Lake Erie. Accepted level of Lake Erie above Ocean level is 573′.

The third column adds 1′ to reduce the levels of the second columns to harmony with those of the Pennsylvania R. R.

It is thus seen that the Depot at Pittsburgh is established from the Atlantic side and from the Lake Erie side, with a probable error of about one foot.

STATIONS.	+ Lake Erie	Ocean Level.	Ocean Level.
Pittsburgh (*a*) I	173.10	746	745
Allegheny.....	165.82	739	738
Outer Depot.....	191.85	765	764
Wood's Run.....	158.65	732	731
Jack's Run.....	156.50	729	728
Bellevue.....	156.50	729	728
Emsworth.....	153.04	726	725
Dixmont.....	149.77	723	722
Glendale	149.30	722	721

a Pittsburgh Union Depot.

STATIONS.	+Lake Erie	Ocean Level.	Ocean Level.
Haysville	149.30	722	721
Sewickley	164.30	737	736
Edgeworth	152.80	726	725
Leetsdale	143.44	716	715
Fair Oaks	143.44	716	715
Economy	143.44	716	715
Economy Switch	143.44	716	715
Baden	138.24	711	710
Remington	138.24	711	710
Freedom	130.94	704	703
Rochester (*b*).....CCCLV	134.24	707	706
New Brighton	178.12	751	750
Beaver Falls	198 83	772	771
Sullivan	293.15	866	865
Wallace Run	322.84	896	895
Homewood (*c*).....CCCLIX	376.76	950	949
Highland	471.28	1044	1043
Summit Cut	481.71	1055	1054
Darlington	408.85	982	981
New Gallilee	385.29	958	957
Enon (*d*).....434	421.61	995	994
State Line.....472			
Palestine 455	422.46	995	994
Leslie's Run.....479			
New Waterford.....503			
Bull Creek.....515½			
Columbiana.....555			
Mill Creek 534			
Beaver Creek 487½			
Green Creek.....461			
Gr. Cr. Siding.....454			
Middle York 461			
Franklin.....506			

b Junction with Cleveland and Pittsburgh.
c New Castle Branch R. R.
d From here on the figures on page of the Geol. Survey of Ohio, Vol. I, 1873. Between Columbiana and Franklin is a station now called Leetonia where the New Lisbon R. R. joins. Neither name nor elevation of this point is given, and therefore no connection can be made with Warren by this line.

CCCLIV. Ohio River Water Levels.

Elevation of points above tide from report of Col. W. Milnor Roberts to Canal Commissioners, November, 1840.

	+Lake Erie	Ocean Level.
Ohio River at Beaver.....	93	666
New Castle Pool.....	222	795
Conneaut Lake.....	509.50	1082.50
Franklin (*a*)	381.50	954.50
Allegheny River at Pittsburgh (*b*)	120.50	693.50

a This datum is especially valuable in the final determination of the absolute level of the Allegheny Valley R. R. system centering here. But the

CCCLV. Cleveland and Pittsburgh R. R.

Levels of the Cleveland and Pittsburgh R. R., were copied from profile in office of Mr. Isaiah Linton, Chief Engineer, Ravenna, Ohio.

Datum: Lake Erie; 573′ above Ocean level.

STATIONS.		Above Lake Erie.	Above Tide.
Rochester (*a*)..CCCLIII		137	710
Beaver (*b*)	138	137	710
Industry.....	125	128	701
Smith's Ferry.....	125	126	699
Ohio State Line		133	706
Liverpool.....	120	120	693
Wellsville	115	115	688
Linton.....	121	121	694
Hammondsville	115	115	688
Salineville	306	306	879
Yellow Creek (as below)			
Yellow Creek Summit..	543		1116
Sandy Summit.....	612		1185
Bayard	503		1076
Mahoning Summit.....	627		1200
Alliance	516		1086
Beech Creek (water)....	446		1019
Beech Creek (rail).....	471		1044
Lima.....	525		1098
Atwater.....	560		1133
Summit in Atwater.....	603		1176
Rootstown	550		1123
Ravenna Public Square..	560		1133
Ravenna Station.....	530		1103
P. &. O. Canal	495		1068
P. & O. Canal, rail on bridge	509		1082
Cuyahoga River water..	456		1023
Cuyahoga River bridge..	474		1047
Hudson Village.....	547		1120
Hudson Station.....	480		1053
Macedonia.....	420		993
Tinker's Creek, (below rail).....	120		693
Tinker's Creek.....	248		821
Bedford.....	368		941
Mill Creek.....	210		783
Newburg	224		797
Cleveland Euclid street avenue	95		668
Cleveland Machine shop	56		629

a Junction with Pitts. Ft. W. & Chicago R. R. 137, (710) is at 350 feet from east end of Bridge. At Rochester Station of that road the elevation is 707.24.

b At Beaver commences a series of levels taken from page 669 of Vol. I, Ohio Geology, 1873.

height of the R. R. track about Allegheny River water at Franklin has not been obtained.

b Mr. Gardner quotes from report of City Engineer, March 15, 1871, (page 655, Hayden's Report of 1873), for Pittsburgh:

Low water, City Datum 699.20
High water, 1852 . . . . . 729.88
High water, 1832 . . . . . 732.95

CCCLVI. River Division C. & P. R. R.

STATIONS.	+Lake Erie	Ocean Level.
Yellow Creek (as above) (*a*)		
McCoy's.....	111	684
Elliotsville.....		
Sloan's.....	125	698
Jeddo.....		
Brown's		
Steubenville (*b*).....CCCL	90	663
Mingo Junction.....		
Lagrange.....		
Rush Run.....		
Portland.....	90	663
Yorkville.....		
Deep Run.....		
Martin's Ferry	86	659
Bridgeport (*c*).....CCLVI		
Bellaire (*d*).....CCLVI	82	635

a Down the west bank of the Ohio.
b Junction with Pittsburgh, Cincinnati and St. Louis.
c Junction with Baltimore and Ohio R. R.
d Junction Central Div. Balt. and Ohio R. R.

CCCLVII. Beaver Levels.

Bench Marks in vicinity of Beaver, Pa., furnished by Mr. James Harper, County Surveyor, who received the information from notes of Mr. J. N. Hoag, U. S. Engineer.

Bench Marks.

23 Cross cut on door sill of National Plow *Company's building in Rochester*, west door, river front 690.365

26 N. E. corner French and Quay's fire brick works, main building, opposite *Beaver station* on east end top of rubble masonry. Cut on top of rock with cross beside it 688.946

25 Cut and marked with a cross on a flat stone 40 feet from foot of alluvial bank toward river, and opposite a point 50′ west of west end of platform at *Beaver station* 670.348

The above levels were brought from Pittsburgh from a Bench, whose reference above main tide was given by the City Engineer, as determined by the Pennsylvania R. R. level.

CCCLVIII. New Castle and Beaver Valley R. R.

Levels on the New Castle and Beaver Valley R. R., were obtained at Pittsburgh, Pa., through the kindness of Mr. F. S. Slataper, Chief Engineer, P. F. W. & C. R. R. (Late survey).

Datum: Lake Erie, 573′ above Ocean level.

This is part of the Ashtabula, Youngstown and Pittsburgh R. R.

STATIONS.	Lake Erie.	Ocean Level.	
Homewood (*a*).....CCCLIII	376.76	950	
Clinton.....	326.97	900	
Thompson's.....	286.53	860	
Wampum.....	228.44	801	
Newport.....	239.36	812	
Moravia.....	233.02	806	
Lawrence Junction (*b*).....	201.09	774	
Mahonington.....	216.04	789	
New Castle (*c*).....	230.29	803	
Covert's Mills.....	217	790	
Edenburg.....	229.6	803	
Seymour.....	224.3	797	
Hilltown.....	225.6	799	
Quakertown.....	244.2	817	
Lowell.....	252.8	826	
Nebo.....	266.5	839	
Struthers.....	263	836	
Haselton.....	257.9	831	
Youngstown.....	264.4	837	
Brier Hill.....			
Girard.....			
Niles.....			
Warren.....			
A. & G. W. R. R. (*d*).. CCCLXV			
Champion.....			
Bristolville.....			
Oakfield.....			
Bloomfield.....			
Orwell.....			
Rock Creek.....			
Eagleville.....			
Austenburg.....			
Ashtabula (*e*).....CCCLXIII			

a Pittsburgh, Fort Wayne and Chicago R. R.

b Junction with Erie and Pittsburgh R. R. at Lawrence. *R. R. track at this point 40′ above water in river.*

c Junction with New Castle and Youngstown Branch of Pitts. Ft. Wayne and Chicago R. R.

d Atlantic and Great Western R. R.

e Lake Shore and Michigan Southern R. R.

CCCLXVIII. Beaver Coals, &c.

Levels of Coal Basins and other points from report of W. G. Darley, Chief Engineer of New Castle and Franklin R. R., Oct. 7, 1864.

	Above Lake Erie.	Above Ocean Level.
New Castle	220	793
Brier Hill (Mahoning Valley)	356	929
Hottenburgh Lower Vein	520	1093
Sandy Lake	740	1313
Sandy Lake, Lower Vein	540	1113
Harrisville	806	1379
Gillande Summit	576	1149
Franklin	417	990
Mercer	500	1073

CCCLIX. New Castle and Franklin R. R.

Levels of the New Castle and Franklin R. R., were copied from a profile of the road furnished by Mr. A. Vandivoort, Supt.

Datum: Lake Erie, 573′ above Ocean level.

STATIONS.	+Lake Erie	Ocean Level.
New Castle (*a*).....CCCLVIII	220.50	793
Eastbrook	333	906
Graham's	334	907
Wilmington	355	928
Neshanock Falls	419	992
Volante	462	1035
Leesburg	472	1045
Nelson	487	1060
Hope Mills	534	1107
Mercer (*b*).....CCCLXI	524	1097
Turner's	571	1144
Jackson Centre	684	1257
Garvin	754	1327
Summit	815	1388
Coulson	704	1277
Stoneboro (*c*).....CCCLXIII	598	1171

a Junction with New Castle and Beaver Valley R. R.
b Junction with Shenango and Allegheny R. R.
c Junction with Franklin Division L. S. & M. S. R. R.

CCCLX. Erie and Pittsburgh R. R.

Levels on the Erie and Pittsburgh R. R. were copied from the profile in the office at Erie, through the kindness of Mr. E. N. Beebout, Asst. Engineer.

Datum: Lake Erie. 573′ above Ocean level.

a Junction with New Castle and Youngstown Branch of Pittsburgh, Fort Wayne and Chicago R. R. Table CCCLVIII.
b Crossing of A. & G. W. R. R. See Table CCCLXV.
c Crossing, Franklin Division, L. S. & M. S. R. R. See Table CCCLXII.

STATIONS.	+ Lake Erie	Ocean Level.	
New Castle (*a*).....CCCLVIII	236	809	
Harbor Bridge.....	243	816	
Nashua.....	248	821	
Pulaski.....	253	826	
Middlesex.....	260	833	
Wheatland.....	268	841	
Sharon.....	280	853	
Sharpsville.....	375	948	
Clarksville.....	321	894	
Transfer.....	417	990	
A. & G. W. R. R. Crossing (*b*) CCCLXV.....	357	930	
Shenango.....	368	941	
Greenville.....	388	961	
Jamestown (*c*).....CCCLXII	406	979	
Kasson's.....	538	1111	
Espyville.....	515	1088	
Linesville.....	460	1033	
Summit (*d*).....	586	1141	
Conneautville.....	493	1066	
Spring.....	388	961	
Albion.....	284	857	
Crosses.....	192	765	
Girard (*c*).....CCCLXIII	124	697	
Fairview.....			
Swansville.....			
Erie.....CCCLXIII			

d The elevation given at a point near Summit is 573′ above Lake Erie = 1146′ above Ocean level.

e Junction with L. S. & M. S. R. R. near Girard.

CCCLXI. Shenango and Allegheny R. R.

Levels on the Shenango and Allegheny R. R. were furnished through the kindness of Mr. Aug. Mordecai, Assistant Engineer A. & G. W. Railway, Meadville, Pa.

Datum: Lake Erie. 573′ above Ocean Level.

STATIONS.	+ Lake Erie	Ocean Level.	
Harrisville.....	767	1340	
Pinegrove.....	677	1250	
Pardoe.....	632	1205	
Mercer.....	535	1108	
Cool Spring.....	554	1127	
Freedonia.....	604	1177	
New Hamburg.....	585	1158	
Shenango.....	364	937	
Greenville (*a*).....CCCLX	388	961	

a The Shenango and Allegheny R. R. connects with the Erie & Pittsburgh R. R. at Greenville.

CCCLXII. Franklin Division, Lake Shore.

Levels on Franklin Division of Lake Shore and Michigan Southern R. R. were copied from the profile in the office of the Company at Cleveland, Ohio, by permission of Mr. J. D. Hawks, Asst. Engineer.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	+ Lake Erie	Ocean Level.
Oil City, east (*a*).....CCCI	436.80	1010
Oil City (*b*)..CCCIV, CCCLXVII	436.80	1010
Reno (*c*).....CCCLXVII	444.50	1017
Two Mile Run.....	422.00	995
Franklin (*d*).....CCCLXVII	444.06	1017
Midway.....	423.01	996
Summit.....	592.02	1165
Polk.....	511.07	1084
Raymilton.....	564.88	1138
Midway.....	600.88	1174
Naples.....	591.78	1165
Stoneboro.....	598.08	1171
Coal Branch.....	626.08	1199
Clark's.....	591.30	1164
Hadley's.....	497.09	1070
Salem.....	424.51	998
A. & G. W. R. R. Crossing (*e*) CCCLXV.....	414.10	987
Midway.....	510.00	1083
Jamestown (*f*).....CCCLX	416.78	990
Turner's.....	487.37	1060
Simond's.....	483.72	1057
Williamsfield.....		
Andover.....	522.20	1095
Richmond.....		
Dorsett.....	444.78	1018
Jefferson.....	368.07	941
Plymouth.....	281.20	854
Ashtabula (*g*).....CCCLXIII	74.52	648

a Connects with Allegheny Valley R. R. See Table CCCI.

b Connects with Oil Creek and Allegheny River R. R., see Table CCCIV, and with Franklin Branch of the Atlantic and Great Western R. R. See Table CCCLXVII.

c Connects with Franklin Branch of the Atlantic and Great Western R. R. See Table CCCLXVII.

d Connects with Franklin Branch of the Atlantic and Great Western R. R See Table CCCLXVII.

e Crossing, Atlantic and Great Western R. R. near Salem. See Table CCCLXV.

f Crossing, Erie and Pittsburgh R. R. See Table CCCLX.

g Junction with Main Line of L. S. & M. S. R. R.

CCCLXIII. Lake Shore and Michigan Southern R. R.

The elevations of the Lake Shore and Michigan Southern R. R. were obtained at Cleveland, Ohio, through the kindness of Mr. J. D. Hawks, Assistant Engineer.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	+ Lake Erie	Ocean Level.
Dunkirk (*a*).....CLXII, CCCVI	24.94	598
Morian's.....	53.15	626
Brockton (*b*).....CCCVI	151.11	724
Portland.....	121.24	694
Westfield.....	123.66	697
Ripley Crossing.....	163	736
Ripley.....	176.75	750
State Line.....	212.18	785
Northeast.....	231.4	804
Moorhead's.....	194.6	768
Harbor Creek.....	157.	730
Wesleyville.....	123.55	697
Erie (*c*).....CCXV	112.5	686
Swanville.....	162	735
Fairview.....	162	735
Girard (*d*).....CCCLX	143.72	717
Springfield.....	90	663
Conneaut.....	78	651
Amboy.....	107.75	681
Kingsville.....	98.40	671
Ashtabula (*e*).....CCCLX	74.52	648

a Connects at Dunkirk with Erie R. R., Table CCXII, and with the Dunkirk, Allegheny Valley and Pittsburgh R. R. See Table CCCVI.

b Connects at Brockton with the Buffalo, Corry and Pittsburgh R. R. See Table CCCIX.

c Connects at Erie with Philadelphia and Erie R. R. See Table CCXV.

d Connects at Girard with the Erie and Pittsburgh R. R. See Table CCCLX.

e Franklin Division diverges from the Main Line at Ashtabula. See Table CCCLXII.

CCCLXIV. Erie City Levels.

Elevations of points in the City of Erie, Pa., were furnished by Mr. Irvin Camp, City Engineer.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	Above Lake Erie.	Ocean Level.
Chestnut Street, at Second Street (Lake Bluff).....	70	643
Chestnut and 26th Street.....	190	763
Water in Reservoir, City Water Works.....	235	808

CCCLXV. Atlantic and Great Western R. R.

The levels on Atlantic and Great Western Railway were copied from a profile of road in the office of the Company at Meadville, Pa.

Datum: Lake Erie. 573′ above Ocean level.

STATIONS.	Above Lake Erie.	Ocean Level.
Salamanca (*a*).....CLXII	811?	1384
Bucktooth.....	798	1371
Red House.....	771	1344
Cold Spring.....	785	1358
Steamburg.....	831	1404
Randolph.....	702	1275
Waterboro.....	690	1263
Kennedy.....	676	1249
Poland	694	1267
Levant.....	683	1256
Jamestown (*b*).....CCCVI	748	1321
Ashville.....	777	1350
Panama.....	855	1428
State Line.....	885	1458
Freehold.....	974	1547
Columbus.....	864	1437
Corry (*c*)..CCCIV,CCCV,CCCIX	866	1439
Concord.....	780	1353
Union	724	1297
Mill Village.....	630	1203
Miller's	579	1152
Cambridge.....	585	1158
Venango.....	556	1129
Saegertown.....	534	1107
Meadville.....	504	1077
Franklin Junction Branch (*d*) CCCLXVII.....	497	1070
Sutton's.....	526	1099
Evansburg	707	1280
Adamsville.....	572	1145
Sugar Grove.....	449	1022
Greenville.....	384	957
Shenango (*e*). CCCLXI	371	944
Transfer (*f*).....CCCLX		
Clarksville.....	412	985
Crawford's.....	318	891
Orangeville.....	370	943
Burghill	483	1056
Johnson's Summit.....	553	1126
Baconsburg.....	390	963
Warren.....	327	900
Leavittsburg (*g*) CCCLXVI	322	895

a Junction with Erie R. R. See Table CLXII.

b Crossing, Dunkirk, Allegheny and Pittsburgh R. R. See Table CCCVI.

c Junction with O. C. & A. R. R. R.; see Table CCCIV. Philadelphia & Erie R. R., Table CCXV. Buffalo, Corry and Pittsburgh R. R., CCCIX.

d Franklin Branch of A. & G. W. R. R. diverges from Main Line three miles southeast of Meadville. See Table CCCLXVII.

e Junction with Shenango and Allegheny R. R. See Table CCCLXI.

f Crossing, Erie and Pittsburgh R. R. See Table CCCLX.

g Junction with Mahoning Division of A. & G. W. R. R. See Table CCCLXVI.

CCCLXVI. Mahoning Division, A. & G. W. R. R.

STATIONS.	Above Lake Erie.	Ocean Level.
Colman's (*a*)	265	838
State Line	259	832
Hubbard's	328	881
Veach Mine	350	923
Doughten's	384	957
Thornhill	280?	853
Youngstown	290	863
Brier Hill	338	911
Girard	310	883
Niles (*b*)	336	909
Warren (*c*)	327	900
Leavittsburg	322	895
Braceville	340	913
Windham	372	945
Garrettsville	455	1028
Mantua	536	1109
Aurora	515	1088
Pond	450	1023
Solan	457	1030
Plank Road	469	1042
Newburg	240	813
Cleveland	24	597

a Junction with Main Line, A. & G. W. R. R.

b Junction with Niles and New Lisbon R. R.

c Junction with Main Line, A. & G. W. R. R.

CCCLXVII. Franklin Branch, A. & G. W. R. R.

STATIONS.	Above Lake Erie.	Ocean Level.
Junction (*a*)	497	1070
Shaw's Landing	524	1097
Cochranton	488	1061
Evan's Bridge		
Utica	457	1030
Sugar Creek	430	1003
Franklin (*b*) CCCLXII	399	972
Reno	441	1014
Oil City (*c*) ..... CCCI, CCCIV	422	995

a Junction with Main Line A. & G. W. R. R. about three miles southeast of Meadville.

b Connects with the Franklin Division of the L. S. & M. S. R. R. See Table CCCLXII.

c Junction with Allegheny Valley R. R., Table CCCI; and with Oil Creek & Allegheny River R. R. See Table CCCIV.

CCCLXVIII. Sharon Branch, A. & G. W. R. R.

STATIONS.	Above Lake Erie.	Above Tide.
Junction (*a*)	329	902
Sharon	285	858
End of Road	275	848

a Junction with Main Line, A. & G. W. R. R., near Sharon.

APPENDIX.

Mountain Summit Levels.

Statement of elevations of Summits of dividing grounds of Eastern and Western Waters.

SUMMITS.	Tide.	Ocean Level.
Nescopeck, N. P. R. R.	1635	
Elk & West Creek, P. & E. R. R.	1677	
Sugar Run Gap	2161	
West of Olean, N. Y. & E. R. R.	1672	
Blair's Gap, Allegheny & Portage Railroad	2339	
Wilson's Gap, B. & O. R. R.	2620	
Sand Patch, P. & C. R. R.	2290	
Clarion, P. & E. R. R.	1979	
Catawissa Extension of Little Schuylkill R. R.	1450	
Elmira, N. Y. & E. R. R.	1419	
Chambersburg & Pittsburgh (*a*)	2547	

NOTE.—The above levels were copied by Mr. G. W. Leuffer from Mr. Strickland Kneass' memorandum, April 4th, 1866, and are supposed by Mr. Leuffer to be from surveys made by Col. Charles H. Schlatter, in 1838 or 1839.

a Summit between Chambersburg and Pittsburgh, on turnpike.

Clearfield County Levels.

Statement of levels in the Clearfield Region furnished by Mr. E. M. Leuffer, Civil Engineer. Add 3′ for Ocean level.

STATIONS.	Tide.	Ocean Level.
Tyrone Junction of T. & C. R. R. and Pa. R. R.	892	895
Vanscoyoc	1402	1405
Gardner's	1553	1556
Mt. Pleasant	1759	1762
Emigh's Gap Summit	2025	2028
Emigh's Gap Summit, Natural Surface of ground	2036	2039
Osceola	1473	1476
Pool, Osceola Dam	1444	1447

STATIONS.	Tide.	Ocean Level.
Mouth of Beaver Run	1444	1447
" Bear Run	1467	1470
" Mountain Branch	1485	1488
" Whiteside's Run	1488	1491
" Wilson Run	1633	1636
Crest of Allegheny Mountain at Middle Summit, 3 Spring Gap and source of Moshannon Cr.	2233	2236
Crest of Allegheny Mountain at Northern Summit, 3 Spring Gap	2278	2281
Crest of Allegheny Mountain, one mile east of Northern Summit, 3 Spring Gap, and highest ground	2611	2614
Crest of Allegheny Mountain in gap between north fork of Sinking Run and Mountain Branch	2406	2409
Crest of Allegheny Mountain in gap between Laurel Run and tributary of Mountain Branch	2364	2367
Crest of Allegheny Mountain in gap between Bear Run and Mount Pleasant Run	2221	2224
Hale's Coal Bank	1638	1641
Davis' Coal Bank on pike, two miles east of Janesville	1670	1673
Little Muddy Run at pike crossing near Janesville	1450	1453
Whiteside's Gap in divide between Moshannon & Clearfield waters	1618	1621
Confluence of Big and Little Muddy Runs	1321	1324
Spruce Flat Summit in divide between Beaver Run and Clearfield waters	1603.5	1607
Confluence of Big Muddy and Clearfield Creek, near Madeira	1302	1305
Houtzdale, Level of top of rail of Railroad at Depot	1492	1495
Franklin Colliery Level of bottom of Coal Vein	1526	1529
Surface of water in Clearfield Creek at Glen Hope	1319	1322
Surface of water in Big Muddy Run at turnpike crossing, $1\frac{1}{2}$ mile west of Janesville	1345	1348
Hagerty's cross roads	1568	1571
Stephen's Summit in Clearfield and Moshannon divide	1722	1725
Sand Spring, source of the Mountain Branch	2428	2431
Moshannon Mines three miles west of Osceola (?)	1465	1468

Centre County Levels.

Elevations of points on experimental line from Bellefonte to Spring Mills, by Mr. J. L. Sommerville, R. E., Bellefonte and Snow Shoe Railroad.
Add 7′ for Ocean Level.

STATIONS.	Tide.	Ocean Level.	
Crossing Nittany Mountain at Heckley Furnace	1867	1874	
Head of Penn's Creek (water)	1129	1136	
Spring Mills intersection with L. C. & S. C. R. R.	1072	1079	
Bellefonte and Lewistown turnpike crossing, Nittany Mountain	1650	1657	

CVII. Lehigh and Susquehanna R. R.

See page 43 above.
The following tables have just been received from Mr. John W. Crellin, A. E., in a letter dated, Mauch Chunk, May 1, 1876.

STATIONS.	Elevations.	Ocean Level.	
Top of rail L. V. Track at Phillipsburg CXIV	217.4		
Easton CVII	215.1		
Glendon	215.06		
Hopes	219.51		
Freemansburg	221.73		
Bethlehem	235.54		
Bethlehem Junction	239.35		
Allentown	257.23		
Lower Catasaugu	271.02		
Upper Catasaugu	283.53		
Lauback's	303.82		
Siegfried's Bridge	315.03		
Priechler's	343.95		
Lockport	356.42		
Walnut Port	371.43		
Lehigh Gap	392.73		
Hazardville	416.83		
Bowmansville	435.77		
Parryville	443.33		
Weissport	475.50		
Lehighton	493.71		
Mauch Chunk	532.3		
Coal Port	584.7		
Penn Haven Junction	708		
Penn Haven	723.9		

CIX. Nesquehoning Valley R. R.

See page 44, above.

STATIONS.	Elevations.	Ocean Level.	
Nesquehoning	801.116		
Hauto	1005.19		
Hometown	1175.64		
Hawk Switch	1221.43		
Pamanend	1287.43		

CXII. Lehigh and Lackawanna R. R.

See page 45, above.

STATIONS.	Elevations.	Ocean Level.	
Bethlehem Junction	239.35		
Shimer's	289.129		
Ritter's	298.67		
Brodhead's	313.077		
Steubens'	333.257		
Clyde	362.387		
Bath	422.687		
Chapmansville	575.927		

Stated Meeting, January 21, 1876.

Present, 15 members.

Vice-President, Mr. Fraley, in the Chair.

A photograph of Prof. Jas. C. Booth was received and ordered to be placed in the Album.

Letters of envoy were received from the R. Academy at Stockholm, and the R. Observatory at Greenwich.

Donations for the Library were received from the R. Academy at Stockholm, R. Academy and Observatory at Turin, Victoria Institute, Nature, Geological Society at Dublin, American Journal of Science, P. & L. Society at Leeds, Antiquarian Society at Albany, Academy of N. S. at Philadelphia, Franklin Institute, Medical Journal, Engineer

Department U. S. A., Congressional Library, Wisconsin Historical Society, and a Committee of the Boston Society of Civil Engineers.

Mr. Chase described a Japanese translation of Dr. Henry Hartshorne's book entitled, "Essentials of the Practice of Medicine."

Mr. Price exhibited a piece of wood, very dry and light, and not at all mineralized, recently obtained from a city well, and desired to place on record the following memorandum:

Two wells for drains have been dug at and near the southern end of the Hotel at the southwest corner of Broad and Walnut streets, the highest part of the old city of two square miles in area. After the surface and brick clay, the digging was through firm blue clay to the depth of thirteen feet from the curb line; then fine gravel; and at the bottom coarse "water gravel," which was penetrated to the depth of 27 feet from the curb, where the digging ceased, without going below that gravel. The lower was the coarsest, with pebbles two or three inches in diameter; and through it were scattered some unrounded stones, with angles more or less sharp, but only a few inches in length, and the largest not over eight inches long. Near the bottom was found the limb of a tree, two inches thick in the broadest diameter.

Mr. Blodget described the clays and gravels underlying the city, and a map of Broad street, from South street to League Island, which he had published to show that they were evenly deposited at about the level of tide.

Mr. Blodget said that, in the borings on League Island which he superintended, the gravel beneath the clay was proved to pass under the water and forms the river bed, affording good holding ground for ships everywhere, the central channel being 33 feet deep, and the inshore soundings 16 feet below low water mark. A little mud is seen at the upper end of the island. The southern end shows a tough clay, which sets or hardens on exposure, and is used for embanking. At Point Breeze, in excavations for the large bank, one foot of quicksand was found 45 feet down, under which lay firm gravel; the series from the surface downward being 1, top loam; 2, sandy clay and blue clay; 3, gravel. Piles 18 feet long driven through blue clay took firm hold in the lower gravel.

Mr Tathem said that at Fifth and Walnut streets there were two gravels, separated by 20 feet of blue clay and mud, a pure slimy blue clay without a particle of gravel.

Morris, Tasker & Co.'s well in Southwark went down 70 feet before striking rock, and continued in the rock to a depth of 250 feet.

Mr. Price said that his present excavations at Twenty-eighth and Oxford

streets, show at 15 feet from the surface a black streak 2 inches thick, the whole mass being gravel as far as they have yet gone.

Mr. Blodget recounted the experience of those who laid the foundations of the Masonic Temple, Broad and Filbert, where two gravels were found separated by 3 feet of quicksand, which required two powerful steam pumps 6″ and 8″ working night and day. The top of the quicksand layer was accidentally uncovered at the corner of the lot 40 feet deep, and this obliged the plan for laying the foundation to be entirely changed at an expense of say $30,000.

The great tower of the Public Buildings opposite to the Masonic Temple, has its foundation laid in the upper gravel, and there is a possibility of future disaster from the subjacent quicksand.

Dr. Cresson communicated also the following record and analyses of the boring at the Continental Hotel, at the corner of Chestnut and Ninth streets:

Analysis of Water from Artesian Well at Continental Hotel and Schuylkill River.

Analysis made by.....Charles M. Cresson, M.D., 417 Walnut Street.
Sample received.....March 22, 1875.
" amount of (U. S. G. = 231 Cubic Inches, = 8.332698)....4 gallons.
Analysis made.....March 23d—April 15th.

Condition of sample.....Small amount of Sediment.
Reaction.....Neutral.

Analysis No. 1442.			Artesian W. Grains in 1 U.S.Gallon	Schuylkill R. Grains in 1 U.S.Gallon
Sediment				
Solid matter upon evaporation to dryness			13.58000	6.99000
" " " " " after ignition				5.06000
Organic Matter (Carbonic Acid, &c.), by loss on ignition				1.93000
Silica		($Si O_3$)	2.11800	0.65000
Alumina		($Al_2 O_3$)	0.42800	0.05100
Oxide of Iron		($Fe_2 O_3$)		0.05900
Lime		(Ca O.)	1.47448	0.94640
Magnesia		(Mg O.)	0.46908	0.53280
Carbonic Acid		(CO_2)	not det.	not det.
Sulphuric acid	free	(SO_3)	none	none
" "	in combination		0.68750	1.18000
Chlorine	free	(Cl.)	none	none
"	in combination		0.65000	0.50000
Potash		(KO.)	chiefly	chiefly
Soda		(Na O.)	potash.	soda.
Ammonia	free	(NH_3)	0.00646	0.00850
"	albumenoid		0.00442	0.02142
Nitrogen from Nitrates and Nitrites			0.18360	0.17000
Sewage			0.04420	0.21420

Well at Continental passed through,	Thickness of strata.	Total depth.
Sand and Gravel to Rock at	40 feet.	40 feet.
Blue Gneiss	100 "	140 "
Feldspar	1 "	141 "
Light Grey Gneiss	38 "	179 "
Pure Feldspar	27 "	206 "
Pump down to	178 "	384 "

Is a purer and better drinking water than that supplied from the Schuylkill, and equally good for household purposes. In March 1874 and 1875 water became muddy for four hours and then clear again.

Mr. C. E. Hall communicated, through the Secretary, a List of Genera and Species of Fossils determined by him during 1874 and 1875, to be included in his report on the Fossils of Pennsylvania for the Geological Survey.

Mr. Lesley communicated a list of 2,500 station-levels in Pennsylvania, collated from railway and other records, by Mr. Charles Allen, of the Geological Survey.

Mr. Chase communicated certain conclusions deducible from the curves of rainfall in North America.

Mr. Lesley was elected Librarian.

The following Standing Committees were appointed for the ensuing year:

Finance,

Mr. Frederick Fraley,
Mr. Eli K. Price,
Mr. Benjamin V. Marsh.

Publication,

Dr. John L. LeConte,
Dr. Daniel M. Brinton,
Dr. Harrison Allen,
Dr. Charles M. Cresson,
Mr. William M. Tilghman.

Hall,

Gen. Hector Tyndale,
Mr. Edward Hopper,
Mr. Solomon S. Roberts.

Library,

Dr. Benjamin H. Coates,
Mr. Eli K. Price,
Dr. Joseph Carson,
Dr. Charles T. Krauth,
Dr. George H. Horn.

Pending nominations 791, 792 were read.

Pending nomination No. 791 was balloted for.

The reading of the list of surviving members was postponed.

The annual report of the Trustees of the Building Fund was presented and referred.

On motion of Mr. Price, an appropriation of $500 was made for the immediate binding of the unbound Serials in the Library.

On motion of Mr. Blodget, it was

Resolved, That a Committee of this Society be appointed to consider the propriety of attempting a representation of the progress of research in Physical Science in the United States at the coming Centennial, and of inviting the co-operation of other Societies in such representations.

Mr. Blodget, Dr. Barker and Dr. Campbell were appointed the Committee.

On scrutiny of the ballot box by the presiding officer, it was announced that:

Dr. J. Gibbons Hunt was duly elected a member of the Society.

And the meeting was adjourned.

NEBULAR ACTION IN THE SOLAR SYSTEM.

By Pliny Earle Chase,

PROFESSOR OF PHILOSOPHY IN HAVERFORD COLLEGE.

(*Read before the American Philosophical Society, April 21st,* 1876.)

In studying the special evidences of nebular action, we find various significant relations, based on the following cardinal planetary positions, for which Stockwell's* values are taken:—

	Secular Perihelion	Mean Perihelion	Mean.	Mean Aphelion	Secular Aphelion	Secular Range
☿	.29743	.31873	.38710	.45546	.47677	.17934
♀	.67224	.69779	.72333	.74888	.77442	.10218
⊕	.93226	.98613	1.00000	1.03387	1.06774	.13547
♂	1.31105	1.40322	1.52369	1.64416	1.73633	.42528
⚳	4.88632	4.97824	5.20280	5.42735	5.51927	.63295
♄	8.73445	9.07764	9.53885	10.00006	10.34325	1.60880
♃	17.68803	18.32298	19.18358	20.04418	20.67913	2.99111
♆	29.59817	29.73221	30.03386	30.33551	30.46955	.87138

1. The minimum eccentricities of the principal planets, as found by Stockwell are:—Neptune, .00557; Uranus, .01176; Saturn, .01237; Jupiter, .0255; Earth and Venus, each, 0. The ratios, counting towards Sun, are, therefore, ♆ ÷ ♃ = 1 : 2.11; ♄ : ⚳ = 1 : 2.07. The closeness of these approximations to the fraction $\frac{1}{2}$, suggests their probable dependence on a fall through a half-radius, which would give the particles of a nebulous ring the velocity of separation.

2. The secular ranges of the planets present many suggestive features. Jupiter's (.63295) corresponds with Earth's orbital radius of spherical gyration (.63245); Saturn's (1.6088), with the nucleal tendency of Earth's kinetic radius, ($1.4232^{\frac{4}{3}} = 1.6009$); Uranus's (2.99111), with the asteroidal belt, and with a linear pendulum of which Earth occupies an oscillatory centre; Mars's, with the centre of linear oscillation of Jupiter's; Venus's, with the centre of explosive oscillation of Mercury's; the range sum of Neptune and Earth, (1.00685), with Earth's mean vector-radius; of Venus and Mercury, (.60462), with the kinetic atmosphere (.60087); the sum-ratio of Earth and Venus, (.23765), with the ratio of Mercury's greatest eccentricity (.23172).

3. Stockwell's estimates for the maximum secular eccentricity, Bessel's for the masses of Jupiter and Saturn, and Newcomb's for those of Uranus and Neptune, give the following values for the positions of centres of gravity, at secular perihelion, mean, and secular aphelion, the unit being Sun's radius:

*Smithsonian contributions, 232, pp. 37, 38.

	Perihelion.	Mean.	Aphelion.	Approximate Ratios.
⊙ ♃	1.0019	1.0668	1.1318	1
⊙ ♄	.5360	.5883	.6347	$\frac{1}{2}$
⊙ ♁	.1681	.1824	.1966	$\frac{1}{6}$
⊙ ♆	.3228	.3276	.3323	$\frac{1}{3}$

These values likewise exhibit a close approximation to the perihelion ratio $\frac{1}{2}$, between the companion planets of each pair, together with indications of nebular rupture between Saturn and Uranus, and of increasing condensation towards Neptune and Jupiter. The perihelion ratio of Neptune: Jupiter = 1 : 3.1; that of Uranus : Saturn = 1 : 3.2, or nearly that of a nodal division, to the entire length, of a linear pendulum. The reversal in the direction of condensation, between the central and the exterior belt, may perhaps explain the retrograde satellite motions of Uranus and Neptune.

4. If we compare the perihelion and the aphelion centres of gravity of companion planets, we find that .6347 is near the centre of spherical gyration $\left(\sqrt{.4} \times 1.0019 = .6336\right)$ of 1.0019, and that .1681 is near the centre of nebular rupture *(.1661) of .3323.

5. The time of revolution varying as $r^{\frac{3}{2}}$, while the time of rotation with the velocity due to interior *vis viva* varies as $r^{\frac{1}{2}}$, the limiting radius of synchronous rotation and revolution, for any given expanding or contracting nucleus, is a mean proportional between the limiting radii of interior and exterior nucleal rupture. I have shown that the gravitating impulses are $4565 \times (10)^{11}$ per second, corresponding in frequency with the red rays of light, and the modulus of light is

$$\left[\frac{365.256 \times 86400}{2\pi \times \sqrt{214.86 \times 497.825}}\right]^2 = 473755 \text{ solar radii.}$$

If modulus were taken as the primitive radius of resisting inertia, $(r)^{\frac{3}{2}}$, Neptune's position would accord with the corresponding nucleal radius ($r = 6077.2$ solar radii), and Mercury's with the radius of internal rupture ($r^{\frac{1}{2}} = 77.96$ solar radii) Saturn's place being fixed, as we have seen, by the centre of nucleal planetary inertia, its *mean* aphelion radius appears to have influenced Neptune's position, while Earth's *secular* aphelion exerted a like influence on Mercury's position; for $1.04835 \times 6077.2 = 6371$, Neptunes secular perihelion being 6359.5, a difference of less than $\frac{1}{3}$ of one per cent.; $1.06774 \times 77.96 = 83.24$, Mercury's mean distance being 83.17, a difference of about $\frac{1}{12}$ of one per cent.

6. The mean proportional between these values of $r^{\frac{1}{2}}$ and r, as well as between Sun's radius and modulus, is 688.3 solar radii, or 3.203 times Earth's mean radius vector, which is near the outer limit of the asteroidal belt. This agrees very closely with the secular range of Uranus (2.99111), and the relation is still closer to the ratio between the gravitating radii of Saturn

*Velocity at $\frac{1}{2} r = \sqrt{2gr}$.

and Uranus $\left\{\frac{5883}{1824} = 3.209\right\}$. The positions of the principal masses in the three chief companion planetary pairs, indicate the same law of mean proportionality, between interior and exterior rupturing tendencies. For Jupiter's secular aphelion (5.5193) is at the geometrical mean (5.5195) between Earth's mean distance and Neptune's secular aphelion (30.46955). Neptune's secular perihelion (29.598) is within one per cent. of 6 × Jupiter's secular perihelion, or in inverse ratio of the indices in my equation of products of figurate powers, ($\Psi^1 \times \mathfrak{F}^3 \times \mathcal{U}^6 = \mathfrak{h}^{10}$).

7. The nodal influence of linear centres of oscillation, on material particles which are subjected to radial "lines of force," is shown in the vector-radii of the three outer planets, (Saturn, *mean aphelion*, 10; Uranus, *mean aphelion*, 20.044; Neptune, *mean*, 30.034). This tendency would be aided by the apparent primitive interposition of Sun between Jupiter and the exterior planets; for Saturn's vector-radius is so small, in comparison with modulus, that the above positions represent the geometrical progression, $(n + 1)$, $(n + 1)^2$, $(n + 1)^3$, as well as the arithmetical pendulum progression, 1, 2, 3, thus satisfying the requirements, both of elastic media and of simple force-lines. The many indications that Jupiter and Saturn were once parts of the same nebular belt, with a mean nodal difference* of 180°, serve to connect those accordances with the figurate equation.

8. As further clews to the significance of the figurate equation, it may be well to note the closeness of the accordance between the mass-ratios $\odot : \Psi$, $6\pi \odot : \mathcal{U}$, and the distance-ratio $(\mathcal{U} : \oplus)^6$; as well as Stockwell's ratios* of mean perihelion and node-motion.

9. The radial light oscillation which is synchronous with the present limit of possible circular revolution, is $10020.^{s}25 \div 497.^{s}825 = 20.128$ Earth's vector-radii, which is also the rupturing radius of the retrograde-satellite and the direct-satellite planets, the difference between the secular aphelia of Saturn and Neptune, (or the vector-radius of Neptune relatively to the nebular planetary centre of inertia), being 20.126; the mean aphelion vector-radius of Uranus = 20.044; the major axis of the November meteors, and the secular aphelion of Uranus, each = 20.68; twice Saturn's secular aphelion = 20.69; the original nebular activity thus combining with the satellite influences, in maintaining Saturn's rings. Moreover, Neptune's secular perihelion = 1.4313 × the secular aphelion of Uranus, (the "kinetic radius" or the limiting radius of equality, towards which I have shown that *all* central forces mathematically tend, being 1.4232).

10. The sum of Uranus's mean, and Earth's secular perihelion vector-radius = 20.0158. The importance of Earth's position, the near approximation of this sum to the cardinal light oscillation (9), and the indications of a somewhat shorter major-axis for the inner meteors of the November stream, encourage us to look for still further evidences of continuing nebular activity, in our own orbit as well as in that of Saturn. If Earth and Uranus were once parts of an elliptical ring, or meteor current, with

* Stockwell, *op, cit*, p. xlv.

Earth sharing Uranus's present maximum secular eccentricity (.077965). Earth, Jupiter, Uranus, and Sun, were connected by the following equation:—Modulus $= 2\pi \times$ the square of Jupiter's mean radius vector $\times$ the time of revolution at secular perihelion (.922035) of a mean-proportionate radius between Earth and Sun $\left(1 : \sqrt{214.86}\right)^{\frac{3}{2}} \div$ (square of Earth's radius $\times$ 1 year). This value of modulus (474250) exceeds the value found by the ordinary methods (473755), by less than $\frac{1}{9}$ of one per cent.

11. The secular range of Uranus, between 17.688 and 20.679, subjects all the intra asteroidal planets, together with most of the asteroidal belt, to the influence of its accompanying light-oscillations, so that all the members of our interior system of dense planets may have been partially built up of materials from a meteoric stream, of which the November meteors are the *débris*. Earth's secular aphelion (1.0677; Cfr. the ratios of $\mathcal{U} \odot$ centre of gravity, 1.0668, and of Jupiter's secular aphelion, 1.0608) was established near the linear centre of gravity of a pendulum, of which the kinetic radius marked the centre of oscillation ($\frac{1}{2} \times \frac{3}{2} \times 1.4232 = 1.0674$). Venus's secular perihelion (.6722), is near the centre of spherical gyration of Earths secular aphelion $\left(\sqrt{.4} \times 1.0677 = .6753\right)$.

12. If we take the primitive light-axis (20.128), and suppose it subjected to repeated oscillations through $\pm$ Earth's mean vector-radius, successive nodal bisections give the following approximations :

$20.128 - 1 = a$	19.128	Uranus.	19.184
$\frac{1}{2}\, a \quad = \beta$	9.564	Saturn.	9.538
$\frac{1}{2}\,(\beta + 1) = \gamma$	5.282	Jupiter.	5.203
$\frac{1}{2}\,(\gamma - 1) = \delta$	2.141	Asteroids.	
$\frac{1}{2}\,(\delta + 1) = \varepsilon$	1.571	Mars.	1.524

13. If the kinetic radius of Mercury's secular perihelion was also the radius of nucleal separation, its secular aphelion (102.438) was near a corresponding atmospheric radius ($1\ 4232^{\frac{4}{3}} \times 63.906 = 102.305$).

14. If the luminiferous, or kinetic æther is the permanent representative of the original hypothetical nebula, in which suns and planets are but floating particles, Faraday's "lines of force" may be due to longitudinal and transverse waves, either of various degrees of velocity but uniform frequency, or of various frequency but uniform velocity, or of velocities and frequencies both varying, in accordance with definite harmonic laws. The luminous, thermal, magnetic, gravitating, cohesive, and dissociating impulses,* all have simple harmonic representatives in the 26th musical octave, which is the special octave of light-proper; the gravitating impulses have also important harmonics in the 46th, 91st, and 92d octaves.

*The "selenium eye" illustrates one of these harmonies. Prof. W. G. Adams, (Proc. Roy. Soc. Jan. 6, 1876; P. Mag. April 1876) says: "the change in the resistance of Selenium is directly as the square root of the illuminating power." This is inversely as the velocity of nucleal rotation. The deflections in the dark (32) and in the strong sunlight (470) give the ratio 14.69; the ratio of emanating force at Sun, to that at Earth's orbit being 14.66.

15. Jupiter, the chief planet in the supra-asteroidal, and Earth, the chief planet in the intra-asteroidal belt, are connected by the following proportion. The number of light-oscillations (log. = 20.699916) which would communicate the greatest gravitating velocity in our system ($\sqrt{2gr}$ at Sun) : the number (log. = 15.822542) in describing Sun's circumference ($2\pi r$) : : velocity of revolution at earth ($1 \div \sqrt{214.86}$) : velocity of gravitating fall at Jupiter $(1 \div 1051.298)^2$, the units of velocity being taken, respectively, at Sun's surface, and at the limit of equilibrium between $\odot$ $\mathcal{Y}$ aggregation or dissociation (1.4232 + 1049.875).

16. The same chief planets are also connected by the proportion : — $\sqrt{\text{Modulus}}$ (688.3) : light-producing wave at the mean-perihelion centre of gravity of Sun and Jupiter ($\pi \times 1.0198$) : : Earth's mean radius vector: Sun's radius. The value of Earth's radius-vector thus found, is 214.842; the value which is derived from the observations which I have thought the most accurate, being 214.86.

17. Jupiter and Sun thus appear to be companion constituents of a binary star, and the point of primitive rupture should be sought at the secular perihelion centre of gravity. Bodies falling toward that point, or approaching Sun, are subject to a force of about 1048 towards Sun, and 1049 towards the slowly moving common centre of gravity. There are, therefore, two nodal points, with the least resistance to motion nearly midway $\begin{bmatrix} 1048 \\ 2097 \end{bmatrix}$ between them. If Sun is gaseous, as Hunt, Faye, and others have supposed, there should hence arise linear oscillations of $2 \times 2r$, synchronous with the circular oscillations of $2\pi r$. The corona may, perhaps, be due to such radial oscillations.

18. The 15th accordance gives for the mass of Sun ÷ Jupiter, 1049.875 — 2 = 1047.875; the 17th, 1049.874 — 2 = 1047.874; Bessel's estimate being 1047.879 ± .235.

19. The discrepancy between the two astronomical estimates for the velocity of light, seems to have arisen from ignorance of the internodal oscillation. Delambre, from his discussion of more than 1000 eclipses of Jupiter's first satellite,* estimated the time of light-passage from Sun to Earth at $493.^{s}198$; Struve, from the phenomena of aberration, at $497.^{s}827$. If the time of traversing 212.86 solar radii is 493.198, the time for 214.86 r should be 497.831, which differs from Struve's value by less than $\frac{1}{1000}$ of one per cent.

20. If Earth was at the nebular nucleal *surface*, when the Jovi-Saturnian ring was nebularly atmospheric, the *vis viva* of interior nucleal rotation varied as r; and the velocity of resulting planetary revolution, as $r^{\frac{1}{2}}$. We thus obtain, for the theoretical time of present solar rotation, $\sqrt{214.86} : 1 : : 365.^{d}256 : 24.^{d}912$. The lowest estimate from observation is Spörer's 24.624; the highest, that of Schwabe, 25.507.

*Stockwell, *Proc. Amer. Asso.* xx. 76-7.

21. The laws of central forces require that provision should be made for radial oscillations, tending towards the time-limit of iso-radial circular oscillations ($\sqrt{32}$ and $\sqrt{8}$); for tangential velocities, varying inversely as the times and directly as the fourth root of central iso-radial *tendencies;* for centres of oscillation in lines of force, and for oscillations between systematic and locally dominant centres. We have already seen (15, 17, 18,) how closely the relative masses of Sun and Jupiter provide for the last requirement; if they provide also for the others, the centre of oscillation for Sun's possible atmosphere should be at $1047.875 - (\sqrt{32})^4 = 23.875$ solar radii. The corresponding height of possible atmosphere, or the height of equality between the velocities of rotation and revolution, is $\frac{3}{2}$ of 23.875 $= 35.813\ r$. This would give, for the time of solar rotation, $365.256 \div (214.86 \div 35.813)^{\frac{3}{2}} = 24^d.856$, differing less than $\frac{1}{4}$ of one per cent. from the *vis viva* estimate (20).

22. The ratio $1 : 32^2$ is also simply connected with the mass and distance of Jupiter's companion planet, Saturn, and so with the centre of planetary inertia. For $1024 + 1025 + .536 = 2049.54$ (3,17), Saturn's mean radius vector being 2049.51 solar radii; $1024 + (35.813 \div \sqrt{.4}) = 1080.625$ is the limit, of which Jupiter represents a centre of explosive oscillation, and the inertial moment at the limit gives the mass of Sun ÷ Saturn; for $1080.625 \times (\frac{3}{5})^2 = 3501.2$, Bessel's value being 3501.6.

23. Among the many harmonies of planetary mass which manifest a dependence on nebular influences, the following are, perhaps, indicative of some of the earliest forms of activity.

a. The masses of Jupiter and Earth are nearly proportionate to the squares of their periodic times × the velocities due to internucleal *vis viva;* $5.2028^3 \times 5.2028^{\frac{1}{2}} = 321.2$; $321.2 \times 1047.875 = 336201$.

b. The influence of *spherical* gyration on Venus (11), seems to be further shown by its ratio to Earth, which is the *square* of the ratio of Uranus to Neptune $(\sqrt{8} : \pi) : \pi^2 \times 336201 \div 8 = 415289$. Hill's estimate of the mass of Sun ÷ Venus is 408134. If the internucleal *vis viva* of Jupiter were taken at secular perihelion, the resulting theoretical mass-denominators would be Earth, 326222; Venus 402460.

24. The masses of the principal planets, therefore, seem to have been primitively determined by the following influences:—Neptune, by the proportion between the time of direct fall to the centre of planetary inertia, and the time of circular revolution; Uranus by the time of describing the same proportional part of a circle, in the circular orbit; Saturn, by equality of nebular *vis viva* with Jupiter, when the two centres of condensation were in opposite parts of the nebular belt and on opposite sides of the sun; Jupiter, by the ratio of variability, between incipient fall to a centre of linear atmospheric oscillation and circular revolution; Earth, by the combined action of *vis viva* and time of revolution; Venus, by the action,

in a spherical mass, of the same force as determined Uranus in a circular disc. The mass-denominators are,

	Theoretical.	Observed.	Authority.
♅ $32^2 + 23.875$	1047.875	1047.879	Bessel.
♄ $\left[\frac{9.539}{5.203}\right]^2 \times$ ♅	3522.3	3501.6	Bessel.
♆ $\sqrt{32} \times$ ♄	19925.3	19700	Newcomb.
☉ $\pi \times$ ♆ $\div \sqrt{8}$	22133.4	22600	Newcomb.
⊕ $5.203^3 \times 4.886^{\frac{1}{2}} \times$ ♅	326222	322800	Newcomb.
♀ $\pi^2 \times$ ⊕ $\div 8$	402460	408134	Hill.

25. These masses, with Hansen and Olufsen's mass for Mars, and Encke's for Mercury, give the following ratios for the extra and intra asteroidal groups :—

	Theoretical.	Observed.		Theoretical.	Observed.
♅	1.0000	1.0000	⊕	1.0000	1.0000
♄	.2975	.2993	♀	.8106	.7909
♆	.0526	.0532	♂	.1019	.1009
☉	.0473	.0464	☿	.0670	.0663
	1.3974	1.3989		1.9795	1.9581

Here is a further approximation, in the inner system, to the square of the outer ratio, accompanied by suggestive indications of the influence of the ratio between aggregating and dissociating velocities $\left(1 : \sqrt{2}\right)$, and of the ratio between the oscillatory and kinetic radii (1.4232 : 2 : : 1 ; 1.405). The outer is about 220 × the inner, or nearly as Earth's radius-vector is to Sun's radius.

26. To the primitive influences others were subsequently added, depending upon mutual actions and reactions, some of which have already been pointed out, and others are obscurely intimated by harmonies which can hardly be regarded as accidental. To this latter class the following may be added:—

a. Jupiter's mass is to Neptune's mass, as $\pi \times$ Neptune's radius vector is to Jupiter's radius vector; Neptune's mass is to Earth's mass, as $\pi \times$ Jupiter's radius vector is to Earth's radius vector.

b. The mass of the intra-asteroidal planets : Sun's mass : : square of Jupiter's secular aphelion : square of light-modulus.

c. The limit of possible solar atmosphere : $6^2 \times$ Sun's radius : : Earth's polar: Earth's equatorial diameter. ($6 = 2 \times 3 =$ product of number of gravity nodal divisions by number of oscillatory nodal divisions in a linear pendulum; Cfr. Jupiter's mass $= 6\ \pi \times$ Neptune's mass).

27. Struve estimated Sun's proper motion at 1.623 × Earth's radius vector per annum, which is .258 times Earth's orbital motion, the motions being, therefore, in the ratio of their densities.

28. If we add the orbital motions of Earth and Jupiter, to Sun's proper

motion, we obtain, in units of Earth's mean radius vector, Earth, 1.258; Jupiter, .6964. Jupiter's proper motion is, therefore, that which is due the "centre of explosive oscillation," ($\frac{5}{9}$), of which Earth is a limit.

These accordances furnish new data for approximating to the primitive parabolic abscissas of interstellar action. For if we take the kinetic radius

$$\left\{\frac{2\ \pi^2\ r}{\pi^2 + 4} = 1.4232\ r = \text{radius of } \textit{mean} \text{ velocity of radial, synchronous with}\right.$$

$$\left.\text{with circular, oscillation}\right\} \text{ and the solar modulus limit of possible atmos-}$$

phere, (35.813 × radius) as determinants, the three known abscissas (ξ; $\xi + \eta + \zeta$; $\xi + 27\ \eta + 729\ \xi$) give the following logarithms for planetary and stellar abscissas:

		Theoretical.	Perihelion.	Mean.	Aphelion.
ξ = solar radius		.000000		.000000	
$\xi + \eta + \zeta = 1.4232^{\frac{3}{4}}$*		.114950		.114950	
$\frac{3}{4}$ ☿	log. $\xi + 10\ \eta + 100\ \zeta$ =	1.678467	1.680602	1.795038	1.885522
$\frac{1}{2}$ ♀	" $\xi + 11\ \eta + 121\ \zeta$ =	1.910966	1.858650	1.890463	1.920003
$\frac{2}{3}$ ⊕	" $\xi + 12\ \eta + 144\ \zeta$ =	2.155219	2.125604	2.156064	2.184527
$\frac{3}{4}$ ♂	" $\xi + 13\ \eta + 169\ \zeta$ =	2.411227	2.324836	2.390112	2.446847
$\frac{4}{5}$ Asteroid	" $\xi + 14\ \eta + 196\ \zeta$ =	2.678989			
$\frac{5}{6}$ ♃	" $\xi + 15\ \eta + 225\ \zeta$ =	2.958507	2.941956	2.969211	2.994855
$\frac{6}{7}$ ♄	" $\xi + 16\ \eta + 256\ \zeta$ =	3.249779	3.206444	3.244704	3.279865
$\frac{7}{8}$ ♋	" $\xi + 17\ \eta + 289\ \zeta$ =	3.552807	3.521682	3.557093	3.589694
$\frac{8}{9}$ ♆	" $\xi + 18\ \eta + 324\ \zeta$ =	3.867589	3.861415	3.867758	3.873951
35.813 M†	" $\xi + 27\ \eta + 729\ \zeta$ =	7.229595		7.229595	
a Centauri‡	" $\xi + 28\ \eta + 784\ \zeta$ =	7.661925	7.657096		7.686009

We have seen (5) that the limits of the planetary system (Mercury and Neptune), were fixed by the radius of internal rupture and the nucleal radius which correspond to the modulus of light. The values $\frac{1}{2}$, $\frac{2}{3}$, $\frac{3}{4}$, &c., represent the points at which particles falling from $1r$, $2r$, $3r$, &c., would acquire the velocity of central disintegration $(\sqrt{2gr})$. The like co-efficients of Mercury and Mars ($\frac{3}{4}$) seem to indicate satellite relations to Earth and Venus; all the abscissas between Mercury and Neptune, are within the range of orbital eccentricities, the greatest deviations of the theoretical from the mean values being those of Venus and Mars, which are less than five

* The nucleal radius varying as the ¾ power of the atmospheric radius. Compare Alexander's ratio for exterior half-planets (*Smithsonion Contributions*, 280, *p.* 5.)

† Modulus, or the double height of virtual fall which would give the velocity of light, bearing the same ratio to the modular atmosphere, as solar radius bears to solar atmosphere.

‡ The least value is given by Norton; the greatest by Denison. There is no reason for doubting that the true value is between the two.

per cent. Jupiter's deviation is about 2.6 per cent.; Saturn's, 1.2 per cent.; Uranus's, 1 per cent.; Earth's, $\frac{1}{5}$ of 1 per cent. The co-efficient-products in the three principal planetary pairs are, ♀ ⊕, $\frac{1}{2} \times \frac{2}{3} = \frac{1}{3}$ = nodal division of linear pendulum; ♃ ♄, $\frac{5}{6} \times \frac{6}{7} = \frac{5}{7}$, nearly $= 2\ r \div$ kinetic radius; ♅ ♆, $\frac{7}{8} \times \frac{8}{7} = 1$. It seems probable that the actual determining orbit was an ellipse, the two foci being within the masses of Sun and *α Centauri*, but the difference between parabolic and elliptical co-ordinates in our planetary system, is not recognizable so near the focus.

Improved Mounted Burettes for Volumetric Analysis.

By J. Blodget Britton.

(*Abstract of remarks made before the American Philosophical Society, December 3d,* 1875.)

More than a year ago (meeting of November 20th, 1874, Vol. XIV, No. 93, p. 189, of the published proceedings) I exhibited several burettes mounted on stands, and delicately graduated for close, volumetric analysis, differing from each other, but each having the screw and spring valve adjustment, and also one of the rod-stoppered kind, having the screw and top spring lever adjustment.

I now exhibit and shall explain three others also mounted, and delicately graduated, yet still more improved.

The shortest one (Fig. 1 in the annexed plate), has a capacity of 100 cc, with its scale divided into tenths, or one thousand degrees. The glass rod inside of the tube is operated by means of a thumb-screw (A) which works against a horizontal lever (B) under the stand. The lower end of the light vertical iron rod (C) inside of the wooden upright of the stand, rests upon the front of the lever, and its upper end encircles the glass rod directly under its knob. By turning the thumb-screw, the iron rod, and with it the glass one, may be raised or lowered, and the vent of the burette opened or closed at pleasure. The flow may thus be completely controlled or instantly stopped.

The second instrument (Fig. 2 in the plate) is between four and five feet long, and has a capacity of 240 cc, with its scale divided into tenths or two thousand four hundred degrees. It is operated with the thumb-screw (A) like the shorter instrument from which it differs in construction only in the position of the screw and lever and shape of the latter. The screw is placed

Fig.1.

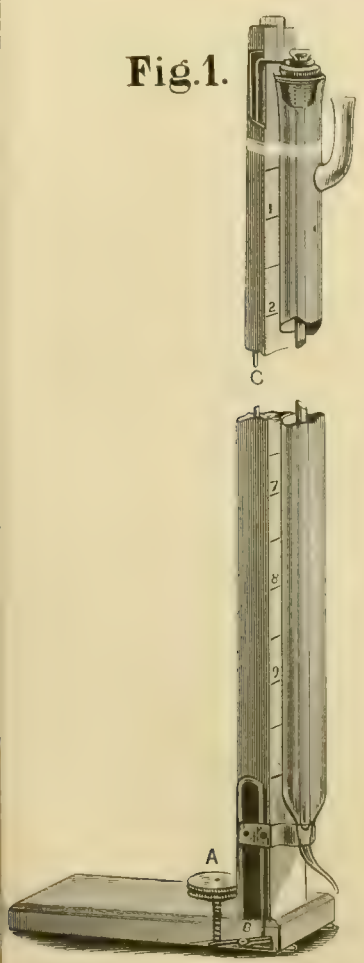


Fig.2.

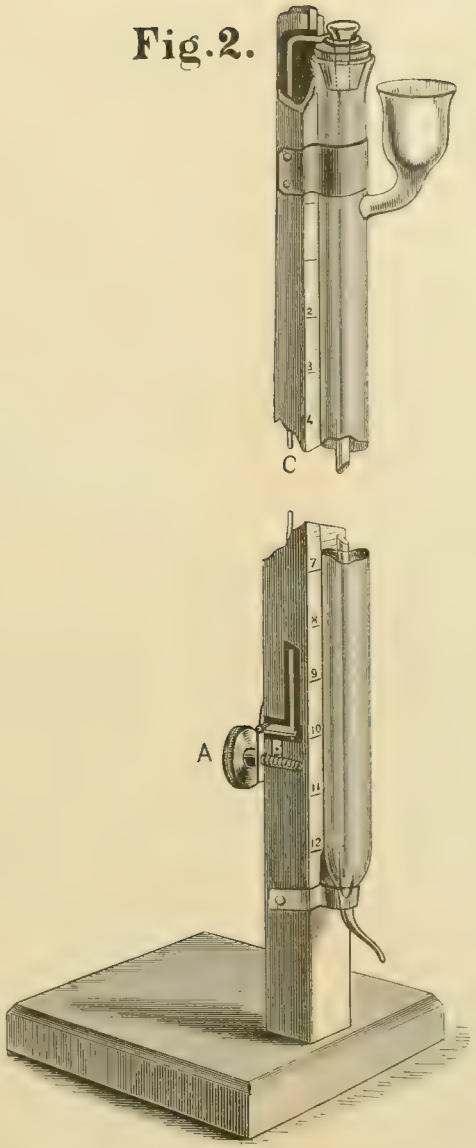
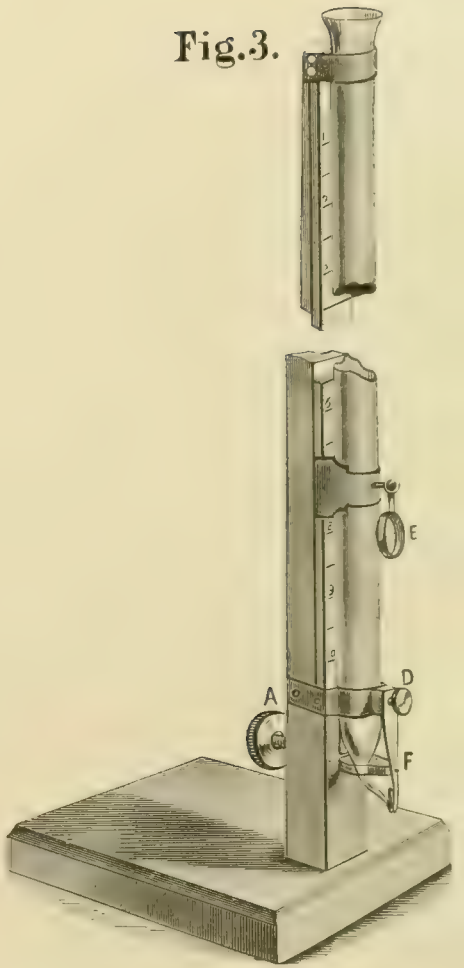


Fig.3.



high up on the upright to allow it to be conveniently grasped when the instrument is being adjusted for use. The eye must at that time be raised to a level with the 0 point of the scale to watch the fluid fall gradually to exactly that point. Should the screw be more than about thirty-four inches below, the hand could not reach it to make the adjustment, its position must therefore depend upon that of the 0 point or length of the instrument.

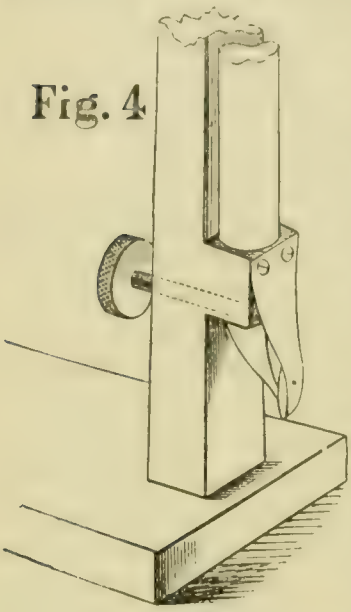
A short burette should have its thumb-screw placed at or near the bottom of the stand (as shown by Figs. 1 and 3 in the plate) to afford a solid rest for the hand while operating; such a rest will prevent any nervous trembling of the thumb and finger when cautiously shutting off the finishing drop.

When it becomes necessary to use a strong acid or caustic alkali, and the analytical work is to be done with great accuracy, I believe that these burettes will give full satisfaction. There is no metal or organic substance about them with which the fluid can be affected—nothing but glass. Leaking to any annoying degree does not occur when the rod is not too light and care is taken to exclude from the tube any granular or solid matter that would prevent the rod from shutting down close; the joint must of course be properly ground, and the opening not too large; but should leaking occur regrinding may be done in two or three minutes by dropping into the tube a few grains of emery flour with some water, and then turning the rod sharply round and round, alternately lifting and pressing it a little. It is best, however, not to neglect to make a note of the reading for any length of time after it can be done correctly. The long instrument will be found very serviceable in a laboratory where many consecutive determinations are to be frequently made, for one filling will answer for several, though it is rather cumbersome for only occasional work, and ordinarily the short one will be preferred. They are exhibited together to illustrate the two ways of placing the thumb-screw and lever.

The third instrument (Fig. 3 in the plate) is of the kind I have had in use for about ten years, and with which a great many thousand iron determinations have been made, always working very satisfactorily. Two of them of different patterns were described in the *Journal of the Franklin Institute* for May 1870, and in the London *Chemical News* for July 5th, of same year. The one now exhibited has a capacity of 100 cc, with a delicate graduation, and is about forty-three inches long, the thumb-screw being nearly thirty-three inches from the 0 point of the scale, and near enough to the bottom of the stand to afford a rest for the hand. It has two improvements, one of which is an adjustable plano- convex lens (E) secured by movable joints to a light, metallic frame. The frame is made to slide up and down easily in grooves on the sides of the upright, and has on its right side a vernier. This arrangement permits the scale to be read with extreme precision, and when not required as in ordinary technical work, it may be slid entirely off, and laid aside. The other improvement, which is a minor one, consists of a single, small thumb screw (D) to hold the spring valve (F) in place, while at the same time it allows the valve to be taken off very conveniently when necessary to remove any matter choking the vent,

and afterwards to be as conveniently replaced. The old arrangement (Fig. 4) required two screws, for the removal of which a screw driver was necessary. I, however, have not adopted the new to the complete expulsion of the old, which costs but a trifle, and in some respects is excellent.

Fig. 4



Notes. Each of these burettes, it will be observed, has its graduated scale on white paper firmly pasted against the upright and behind the tube, and not cut on the tube itself; the graduation consequently is as distinct as it is possible to make it, and the reading being *over* the fluid, which affords a *level* to guide the eye, is done with the least liability to error. In this manner the finest of my burettes have been made. When the cutting is on the tube, I prefer it to be behind, and not in front, and well rubbed with lampblack and oil, and have a white paper pasted on the upright for a ground to make it more plainly seen.

Each tube has its lower end drawn out small enough to just allow a stout hog-bristle to pass freely in and out of the vent, and in order that the discharge may be made sufficiently far over into the receiving vessel, it is bent outwards with the point downwards, so that the vent shall be an inch and a half from the upright, and three inches from the bottom of the stand. The rod-stoppered tubes have their points made smooth by fusion, but the spring valved have theirs carefully ground on an emery plate to allow the valves to shut quite true and tight with the line of contact just vertical, and not at an angle.

Unnecessary thickness of glass about the points is avoided, and the valves are made small, especially at their lower ends, to give as little surface of material as possible for the retention by capillary attraction of the dropping fluid. To further obviate such retention, my practice is to occasionally rub the points and valves with a little pure tallow, the effect of which is excellent. Burettes made in the manner described, may with their valves wide open be discharged of 100 cc in about two minutes. But when there is a rapid discharge, a considerable quantity of the fluid is held back on the walls of the tube by attraction, and the quantity so held becomes increased with increased rapidity of discharge; this is shown most distinctly when a strong solution of chameleon is used, for the material gives color to the tube so long as any of it remains. A rapid discharge consequently will not permit a prompt reading, and if the tube be long some minutes must elapse before all of a fluid, of any considerable density, reaches the bottom. The case, however, is different when the discharge is moderately slow and uniform; the reading may then be done usually soon after the reaction has

been effected. Against hasty work, therefore, beginners should be specially cautioned, and a slow discharging instrument would be best in their hands

I have experimented in years past, as stated at a former meeting, with valves made of quite a number of substances, hard and soft. Of the hard sort, glass when ground true and cushioned behind, afforded a tighter joint than metal, and gave altogether the most satisfaction, but still with ordinary every day usage would not keep in order, and withstand the pressure of a full column of fluid without leaking more or less. Of the soft sort, rubber and fine grained cork were the best; the latter proved most excellent when solutions of potassium permangenate and bichromate were used, for, while always giving a perfectly tight joint, and being sufficiently durable, it became *absolutely inert, and never got sticky from applications of tallow* like rubber. Cork has been in use at the Iron-Masters' Laboratory constantly since 1866, and I still prefer it for my purposes; when cut perfectly true and rubbed with tallow, it will make a valve from which globules no larger than the head of an ordinary pin can be discharged at will. I attach it to the spring with a rivet, and sometimes with a cement; for attaching thin rubber I have used a cement and also a benzine solution of rubber. For springs I have used platinum, brass, steel, and common tin plate.

Of the instruments exhibited, the rod-stoppered kind have the advantage of universal application, but the spring valved kind have more solidity and compactness, and will bear much rougher usage.

The one described by George A. Kœnig, Ph. D (Vol. XIV, No. 93, p. 218, of the published proceedings) is the short, graduated tube furnished by the dealers, to which is fitted the thumb-screw, and spring valve adjustment, the screw working through the spring, and not against it. It is not permanently mounted, and must be used like the one long ago proposed by Mohr (See side view Fig. 5). He states that by putting a hinged joint to the spring he has been enabled to use a platinum valve with a 30 cc tube, the delicacy of the hinge though, was found to be an objection, making the valve liable to get out of order. He further states that a spring coated with rubber will resist the action of standard acids. The instrument is substantially what had been produced years before, and, as must be obvious, is not so perfect as the permanently mounted one.

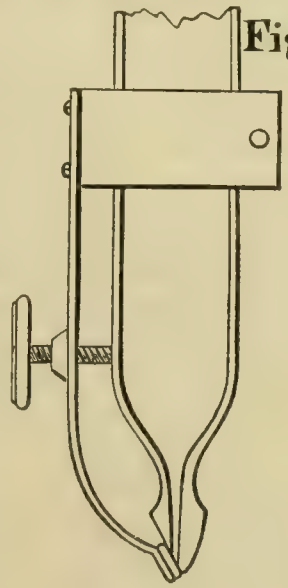


Fig. 5

Stated Meeting, February 4th, 1876.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of envoy were received from the Botanical Gardens, at St. Petersburg, December 19th, 1875, and from the Albany Institute, January 28th, 1876.

Letters of acknowledgment were received from the New Bedford Public Library, 93,94; New York Historical Society, 95; and Rantoul Literary Society.

Donations for the Library were received from the Asiatic Society, Japan Branch; R. Academy, at Brussels; Royal Astronomical Society, in London; London Nature; Peabody Academy at Salem; Boston Society of N. H.; Mr. Edmund Quincy; American Journal of Science, and Professor Marsh, of New Haven; Albany Institute; Society of N. S. Buffalo; American Pharmaceutical Association; A. Journal of Pharmacy; Penn Monthly; Medical News; Social Science Association at Philadelphia; and U. S. Department Interior.

The death of John C. Cresson, first Vice-President of the Society, was announced by Mr. Eli K. Price, as having taken place January 27th ult., aged 69 (born March 16th, 1807).

On motion of Mr. Price, Mr. Fraley was appointed to prepare an obituary notice of the deceased.

Prof. Hart made a statement of the arguments for and against the genuineness of the "Death Mask of Shakespeare" said to have been discovered in Germany, illustrating his remarks by photographs of the principal portraits of Shakespeare, and of the mask in different positions.

Mr. Chase made reference to the paper of Dr. D. Ast, in the American Journal of Science and Arts for January, 1854, reproduced in the American Chemist for May, 1875, on observations on the spectra of metals in the electric circuit.

Pending nomination No. 792 was read.

Mr. Fraley reported the receipt of $150.40, the dividend from the Michaux legacy last due, January 1st, 1876.

Mr. Blodget, on behalf of the Committee appointed at the last meeting, made a preliminary report, and the meeting was adjourned.

Stated Meeting, February 18th, 1876.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

A letter accepting membership was received from Dr. J. Gibbons Hunt, dated Philadelphia, February 4th, 1876.

A letter respecting the action of the Society on the subject of the Polaris Expedition was received from Admiral Davis, dated Washington, February 15th, 1876.

A letter respecting a coin of 1670, the date of the settlement of Quebec, struck by order of Louis XIV, and making the first currency of French North America, was received from Prof. Charles E. Anthon, dated, College of the City of New York, February 11th, 1876, desiring to learn whether the Society would accept the coin, and place a record of its character in their Proceedings.

A letter of envoy was received from the U. S. Naval Observatory at Washington.

Letters of acknowledgment were received from the R. Danish Academy, January 15th (XVII. 93, 94); Essex Institution, February 5th (95); Boston N. H. S. (95; and asking for Vol. V, N. S. and 94); and the U. S. Naval Observatory, February 4th (95).

Donations for the Library were received from the Society at Dresden; the Geographical Society at Paris; the Editors of the Revue Politique; Nouvelles Météorologiques; Revue Philosophique; and Revue Historique; the British Association; Geological, and Meteorological Societies; Nature; Mr. Sam. Birch of the British Museum; Liverpool L. and P. Society; Franklin Institute; Medical News; Prof. E. J. Houston; and U. S. Naval Observatory.

The Committee on Dr. Valentini's memoir was continued.

The death of Mr. Charles des Moulins, at Bordeaux, on the 23d December, 1875, was announced by letter.

Mr. Blasius read a defense of his theory of storms.

A Brief Discussion of Some Opinions in Meteorology.

By W. Blasius.

Read before the American Philosophical Society, February 18th, 1876.

The definite establishment of the laws which regulate the weather is of so much general importance that I am induced to ask your attention to the following remarks, since the discussion of opinions cannot fail to elaborate the truth at last.

In the January number of the Atlantic Monthly, there appeared a fair-tempered review of my recent work on "Storms," which seems to be from the pen of a practical meteorologist, between whom and myself, therefore, I am the more anxious that there should be no misunderstandings. The reviewer does not deny nor admit the truth of the theories I have advanced, but leaves them to the verdict of time.

He in some important particulars, however, fails to understand the views I hold. Permit me to quote:

"The West Cambridge Tornado, which first decided the direction of our author's meteorological studies, seems to have had a too powerful influence upon his judgment of the 'cyclonists,' the upholders of Redfield's Theory. Where a cyclonist sees a large storm 500 miles in diameter, on the borders of which the winds are blowing in every direction, Dr. Blasius sees many small storms, each modeled in a greater or less degree like the West Cambridge Tornado. A very striking proof that a storm may be constituted as the cyclones are supposed to be is afforded by the singular case of the ship Charles Heddle, which was caught in the borders of one of these cyclones, and sailed five times completely around its border, meeting winds blowing exactly in the directions demanded by the cyclone theory. The experience of Dr. Blasius has been limited to local storms, and he has apparently never been able to realize the existence of a storm of any magnitude.

This is particularly evident in the discussion of Prof. Abbe's report on the Nova Scotia storm of August 23, 1873. Prof. Abbe is speaking of a storm at least 500 miles in diameter, but Dr. Blasius discusses it as if it were an assemblage of tornadoes each 1,200 feet wide."

Now the statement that where "a cyclonist sees large storms," I see "many small storms" is curious enough, since a considerable part of my

book is devoted to an attempt to prove that in many cases where the U. S. Signal Service and other cyclonists see "many small storms," each independent of the other, there is in reality one large storm hundreds of miles in width.

And as for the fact that "a storm may be constituted as the cyclones are supposed to be," the position I have taken is not that there are *no* cyclones, but that there are none in our latitude, and that the theory which would make all storms cyclones is radically erroneous. The citation of the Charles Heddle case, to which I have also alluded in my book, is not a very fortunate one, however, since it is far from being authentic. Even Dove himself, the great apostle of the cyclonic theory, calls it a "sea romance," "oder auf gut muselmænnisch gesprochen, etwas was gesehehen sein kœnne, wenn es dem Propheten so gefallen hætte."

Even if it were authentic, however, it would not conflict with any position I have taken, since the storm to which it relates was a typhoon of the Indian Ocean.

The complaint that my experience has been limited to local storms, shows some confusion of ideas, since it is not to be supposed that extensive storms have avoided me, or that the researches of others are not open to me. The reviewer in another place says:

"If Dr. Blasius's book were not dated from the Atlantic coast, the meteorologist could yet determine quite accurately his latitude and longitude from the types of storms he gives."

This is quite satisfactory, since the professed aim of my book is to give general principles, capable of universal application, and then to show how these principles are applied to our latitude as example of the modifying effect of differing local circumstances. Meteorology is largely a science of locality, after all, as well as of the air; mountains, lakes, forests, the sea—all have their effect in determining how the general weather changes will affect us. And this is the reason why predictions for a large section of country, such as the signal service give can never be so accurate as to be of much use.

That I have endeavored to show how general principles could be locally applied, probably affords the Atlantic Monthly reviewer ground for supposing my views restricted; but he cannot have read the book very carefully. So far from not being able "to realize the existence of a storm of any magnitude," it is one of the main points of difference between the cyclonists and myself that, whereas they consider the area of low barometer *the* storm, my views make this but a part of the storm, which covers also much larger areas of high barometer in front and rear.

The particular case cited, that of the Nova Scotia storm of August 23, 1873, is not at all to the point, since, instead of taking a more limited view of the phenomenon than Professor Abbe does, I hold that the storm was twice as large as Prof. Abbe supposes it to have been, and that one-half of it the Signal Service never knew at all. More than this, the half they did not see was that which was on land within their jurisdiction, and was the real

cause of most of the tremendous destruction that occurred. The Signal Service maps of this storm merely note an "area of high barometer" coming from Manitoba on the 22d, to which they attach no significance, and which they do not connect with the Nova Scotia storm; but I feel convinced that this very same "area of high barometer" really an advance of heavy air from the North, was responsible for the loss of most of the thousand and odd vessels that were destroyed on the coast. If the Signal Service had only known its true character, they would have been able to give, at least a day ahead, forewarnings of this most terrible storm which, as it was, took them entirely unawares.

In these "areas of high barometer" the cyclonists see an inexplicable something which they call an "anti-cyclone;" in which they think the air rotates in the opposite direction from that in a cyclone, and that it brings dry and fair weather. The celebrated Le Verrier, acting on this theory, on account of the advance of such an "area of high barometer" over England, predicted fair weather just before those violent storms and terrible floods which last Summer desolated so large a tract of country in France. The theory which I hold would have shown him in this "area of high barometer" an advance of the polar current, almost certain in the Summer season to produce violent rains. It was much the same case with the Nova Scotia storm.

As for the statement that I have discussed this storm as if it were "an assemblage of tornadoes," (*sic*) I do not see any evidence of a tornado at all. A tornado is only a local incident—although a terrible one—in the passage of a Southeast storm, caused principally by the configuration of the ground, notwithstanding that the Signal Service describes one as "at least thirty miles," and "probably 240 miles" in diameter.

The Atlantic reviewer states that, "as a matter of fact, the Signal Service notes all storms within the limits of the Atlantic coast and the Rocky Mountains," and "its object is to obtain the laws of them as they exist." In my book I have pointed out several instances where the advance of the polar current, producing a Southeast storm of considerable magnitude is treated by the Signal Service as a series of detached local storms, such as tornadoes, hail-storms, cloud-bursts, etc., of which they know nothing until they are over; cases of this kind are abundant in the Signal Service reports. If the object of the Signal Service is to establish laws, why—I ask it in no hostile spirit—has it as yet given no laws to science? Or why does it, as the New York *Nation* lately says, "Keep as widely as possible aloof from the science of the country?"

I have also protested against the practice of observing only at fixed hours of the day, contending that if an individual storm is to be known, it must be observed continuously so long as it lasts. The Atlantic reviewer thinks it is not necessary for the Signal Service to do this, because "these (continuous observations) are easily accessible in the quarterly reports of the meteorological office of England!" Upon this method, if you wish to know what are the distinctive characteristics of an African elephant, all you have

to do is to get some one's description of an Asiatic elephant, and draw your own conclusions. Mr. F. Gaster, of the London Meteorological Office says upon this point, that at Valentia, where observations are not made between the hours of 8 A. M. and 2 P. M. "Storms have been overlooked, which would doubtless have been noticed at the Central Office, where the weather is observed continuously." Is it not at the least very probable that the Signal Service, making but tri-daily observations, has overlooked storms in the same way?

In my book I urge that observations of the clouds *in connection* with ærial currents is of the greatest importance, which the Atlantic Monthly writer attempts to meet by saying that the Signal Service has made tri-daily maps of the clouds for four years. This may be true, but it has never made observations of the intimate connection of the clouds with ærial currents, nor understood this significances. Early in 1874 I explained my views to Prof. Henry of the Smithsonian Institute, in a personal interview, and he then said, "This is all new to me." He took copious notes. The Signal Service report for 1873, published after this, contains a few old plates of the cloudforms given by Howard, Pœy, and others, but with no reference to them in the text. That of 1874 contains cloud maps for one day, with no reference in the text, and contains no attempt to give the particular forms any distinctive character. The eminent meteorologist, Prof. H. Mohn, Director of the Royal Meteorological Institute at Christiania, Norway, in a letter to me says: "That you *introduce* the cloudforms into practical meteorology is certainly very good." It is of little use to make maps of the clouds unless we understand something of their significance.

The reviewer states that I claim for myself in conjunction with ex-President Hill, of Harvard, "the credit of originating the present Signal Service storm-warnings," but that we "were anticipated by Redfield, Henry, and others." A claim of this kind is hardly worth advancing or discussing, but I wish to correct misunderstandings. All I do claim is that in 1851, before any one else, I believe, I advocated and labored for a corps of meteorological observers connected by telegraph with a central office, so that the central observer might see the whole storm continuously in all its extent from beginning to end.

I would earnestly urge a popular interest in meteorology, since no other science is so open to those occupied in other pursuits, and scarcely another of so much practical importance. We all know men of no scientific acquirements, yet who are so well versed in signs of the weather that their predictions are more to be relied on for a particular locality than the very general "Probabilities" of the Signal Service. Such weather-wisdom is founded upon accurate observations of nature, and the explanation of weather signs is often very simple. For instance, it is an old Indian observation that Summer storms follow the course of rivers. The explanation of which is that Summer storms are mostly produced by the advance of colder air, which being heavier, sinks into and follows the valleys, at the bottom of which there is usually a water-course. Again, a halo round

the moon indicates rain, since its cause is the partial obscuration of the moon by the first hazy clouds of an approaching Northeast storm. With a knowledge of the connection between the clouds and movements of the air, it will be comparatively easy for any one to predict for his own locality the weather he is to expect from day to day. That this is practicable, is proved by the experience of many, and by an able article on the subject in the Galaxy Magazine for November, by Mr. F Whittaker.

In connection with the importance of clouds in practical meteorology is the following statement in the scientific record of Harper's Monthly for August, 1875, edited, I believe, by Prof. Spencer F. Baird, of Washington.

"Dr. Hildebrandsson, of Upsala, has published the results of a careful study of observations of cirrus clouds. Having secured by personal correspondence a number of careful observers throughout Europe, he has compared the observed movements of cirri with the prevailing clouds and isobars at the surface of the earth. He finds that the cirrus clouds, in a large majority of cases, flow *out* from areas of *low* barometer, and *in* toward areas of high pressure, and, as he succinctly expresses it, the movement of these clouds is toward a point some distance to the right of that toward which the lower clouds move. We had occasion, a few years ago, to announce precisely the same law, as deduced by Prof. Abbe for the United States. It would seem, therefore, a law applicable to the whole of the northern temperate zone, and is entirely in accordance with the mechanical theory developed by Mr. Ferrel in a memoir published in 1860."

The same fact is referred to in Harper's Weekly, January 15, 1876, as follows: "Clement Ley so well known by his investigations into the movements of storms, states, in reference to the movements of cirrus clouds, whose laws have been investigated by Hildebrandsson and others, that his own observations fully confirm those of the latter as to the motion of the upper clouds, with only this modification, that the vertical axis of a revolving storm, about which the whole mass of air may be supposed to rotate is not exactly vertical, but inclined backward."

The writer evidently considers this isolated fact a very important discovery, and it really is the first attempt on the part of the cyclonists to consider the motion of clouds as well as their forms, and I might almost say the first step towards bringing the clouds into connection with storms.

As the cyclonists see the storm in the "area of low barometer," and the opposite of the storm in the "area of high barometer" their "*anti*-cyclone," it is natural that they should describe the motion of cirrus clouds in relation to these phenomena. But as the origin and nature of these phenomena are as yet unknown to them, the cause of the motion of the cirrus clouds in the direction described remains also unknown, and forms thus another puzzle besides the many we have already in the science.

As to the precedency in the discovery of the fact in question, I would draw your attention to my article—"New Theory of Storms," in the New York Times, November 18, 1852, reprinted and more fully elaborated in my recently published work—"Storms, their Nature, Classification and

Laws." It will be seen from this article that I observed the fact as to the motion of cirrus clouds besides others of a like nature about a quarter of a century ago, lectured on it publicly and published it. Copies of the article were sent to Prof. Henry and Lieutenant Maury in Washington. This article which was a sketchy summary of my investigations, contains also the laws of the motions of the lower cloudforms, such as cumulus, cumulo-stratus, conus. And it contains not only the laws as to the direction the different cloudforms take, but also an explanation of the causes of their motion, and the application to the prediction of storms. I mention these facts to show the overpowering influence of recognized authority in accelerating or retarding the development of a Science. Truth of the greatest importance often remains unnoticed if it does not pass first from the lips of a well-known authority, and errors may be propagated for centuries under the shadow of a great name. Although late, it is gratifying, however, to see my observations confirmed as the heavy train of Science moves onward.

Another reason why my observations have remained unnoticed so long, may also be found in the circumstance that I have seen and described meteorological phenomena from a different standpoint from that generally taken. A circular ring will appear to one as a straight line, to another as an ellipse, and to a third one as that what it really is, according to the standpoint from which it is viewed. This is very apparent in looking at phenomena the whole of which we cannot see at once, such as the motions of heavenly bodies or storms; we then are likely to take things as they appear to be. So men thought for centuries that the sun moves and the earth stands still, and the cyclonists think even now that the wind in a storm moves around in a circle, or in an ellipse, or in a spiral, because it appears so. They see in the "area of low barometer" the whole storm, while I from my standpoint see in it only the effect of the storm. The cyclonists see in the areas of *low* and *high* barometer independent although unexplained phenomena; to me these phenomena appear to belong together as organic parts of the storm and assume thus a meaning. With me a progressive storm consists in the displacement of one of two opposing air currents by the other, which is of different temperature, and the area of low barometer forms itself during this conflict between them by the rising of the warmer current obliquely over the colder one. The rising air produces lower pressure, but the full weight of each current produces the areas of high barometer in front, and in the rear of the area of low barometer. I, therefore, see the storm extend over much larger area than the cyclonists do.

I see in the ærial currents the elements of the storm, the cyclonists seem to consider them as the consequence of the storm. I, therefore, naturally consider the motion of the different cloudforms in reference to the ærial currents, and not in reference to barometric pressure, but the facts of their motion are and remain the same.

The "cirro stratus" of Howard—in fact all cirrus clouds—move with the

warm equatorial current, because they are originated by it as it ascends into colder regions obliquely over the colder polar current. The "cirro-stratus" I described in the Times article in 1852 as the embodiment of a fully developed north-east storm, because I found it characteristic by my observations of an approaching equatorial, warm current. I, therefore, consider it an elementary form, and proposed the single name "stratus," used by Howard hitherto for ground fog, which I consider of no form. The name "stratus" admirably indicates the stretched-out, straight-line cloud; it represents with my two other elementary forms—cumulus, conus—geometrical forms and is therefore easily described. The other forms of cirrus, commonly known as mare's tails, cat's tails, etc., are mere modifications of the stratus (cirro-stratus of Howard) forming during the first irregular attempts of the rising warm current before it has assumed its regular lateral motion in which the cirrus forms assume that of the stratus at the top of the regular front waves. We therefore see "the cirrus clouds flow out from areas of low barometer" (the place of the obliquely rising warm current) "and *in* toward areas of high pressure" (the colder polar current). My article twenty-four years ago, therefore, tells not only the facts about the motion of cirrus cloud which Hildebrandsson, Ley and Abbe have recently observed, but also the cause. Besides this it contains the practical application to predict from the appearance of these clouds above the southern horizon the coming of the equatorial current, or the approach of a north-east storm. While thus from the standpoint of the cyclonists the cause of the empirical fact cannot be explained, it follows as a natural consequence when seen from the standpoint I have taken.

The article in question contains also the laws of the motion of lower cloudforms, such as the cumulus, cumulo-stratus, and conus, and why they take their respective course, and how the movement and condition of the currents of which they are characteristic, i. e., the storm may be predicted by their appearance. The study of cloudforms *in connection with ærial currents* is one of the most important duties of practical meteorology.

As to Clement Ley's proposition, "that the vertical axis of a supposed revolving column of air is not exactly vertical, but inclined backwards," I would call your attention to a third opinion held by some most eminent meteorologists, such as Dove, Reid and Redfield, that the axis is inclined forward. The cyclonists run here again into a fresh contradiction, and create a new puzzle, some saying the axis lies forward, some it lies backward, and others it is vertical. It reminds us of Redfield and Espy's discussions, where one maintained that the wind in a tornado moves around in a circle, the other that it blows in straight lines toward the centre. These discrepancies are a consequence of the mode of investigation universally followed in this science, which is to deduce results from a conglomerate mass of disconnected data, obtained indiscriminately from storms that may differ as widely in origin and character as a bat and a sparrow. What have we gained towards an individual knowledge of either the bat or the sparrow by eliminating from a number of data the mean velocity and the

average direction of their flight? We mix things that do not belong together and arrive at best at indefinite, vague and unreliable results. This evidently has happened in determining the direction of the axis of a supposed revolving column of air.

The discrepant views of the celebrated meteorologists above mentioned, will all harmonize if considered from the standpoint indicated in my recent work. The supposed revolving column of air is seen from my standpoint as the obliquely rising equatorial, or warm current; its direction always inclines towards the north, or colder region. It thus coincides with the position of the axis of the supposed revolving column; in a north-east storm it is inclined forward, in a south-east storm backward, in a local storm it is vertical. The method of averaging will lead to the first result if the cases subjected to investigation belong all or in the majority to north-east storms; it will lead to the second result if the cases subjected to investigation belong in the majority to south-east storms; it will bring no result, or make the axis vertical if the cases or data subjected contain a number of both kinds in equal proportions.

Mr. Blodget remarked that there were very striking and valuable suggestions in Mr. Blasius' paper.

He thought that it was true that the influence of the Signal Service was in danger of being weakened by its persistent observations of only three hours in the day. Storms require observation continuously during their course. He agreed with Mr. Blasius, also, in accounting of inferior values other elements of the discussion of storms, those areas of low and high barometer which almost exclusively occupy the S.S. maps. He described the remarkable storms of 1873, accompanied with disastrous floods. They were not parts of a common storm usual to the Temperate Zone, raining from the lower portions of the atmosphere coming from the Gulf; but on the contrary, they were numerous local furious downpours from a hot supersaturated upper air coming from some more distant, unknown region in the South. They had the characteristics of tropical storms, and were so local, that in some instances a distance of only twenty miles sufficed to distinguish a flooded locality from one on which no rain fell. Mr. Blodget added, that, having in former years participated in the discussion of Espy, Redfield and Hare, he could meet the vertical theory with an expressed conviction of the impossibility, quite demonstrable, that a large storm should rotate upon the rough surface of the earth; although it must of course remain true that any disturbance in fluids has a tendency to set up vertical movements. The vast obstructive friction of the face of a country in the case of great air movements must always prevent any rotation over wide areas. Local tornadoes may produce small whirlwinds, but a Redfield cyclone is a physical impossibility. He had found in Mr. Blasius' book more of a true explanation of the origin and progress of storms than elsewhere. While Mr. Blasius had proposed the Signal Service system in 1851, he had himself used the telegraph in the Summer of 1852 for two months; and his charts

of that date show that he proved thereby, and then, the practicability of precisely determining the form and limits of any storm. All that he asked of the Signal Service now was to make continuous observations, instead of three observations a day, and to put down upon their charts the other more important elements with that of barometric pressure.

Prof. Houston noticed the fact that, by the barometer at the High School, the mercury stood, on the 5th of February at 1.20 P. M., at the most extraordinary height of 30.94. He wished also to put on record his proposed improvement of the barometer, at the mechanical details of which he is now working, viz: to read with greater ease and precision, by means of a scale floated on the surface of the mercury, counterbalanced and connected with a ring around the tube.

Prof. Sadtler, by permission of the Geological Survey of Pennsylvania, gave the scientific results of his recent analyses of gas from several oil wells in Western Pennsylvania—gas which is used in the iron manufacture.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. VI.

On the Composition of the Natural Gas from certain Wells in Western Pennsylvania.

By Samuel P. Sadtler.

(*Read before the American Philosophical Society, Feb.* 18, 1876.)

Having had occasion lately to analyse some of the gases issuing from wells in Western Pennsylvania, I have obtained some results which are given as a contribution to our knowledge of these important natural products. There have been almost no analyses whatever made of these gases. In 1866 a French geologist, M. Foncou visited a number of these gas-wells and collected specimens of the gases. These were afterwards analysed by M. Fonqué, and the results are published in *Compt. rendus LXVII. p.* 1045. The localities were Pioneer Run, Venango Co., Pa.; Fredonia, N. Y.; Roger's Gulch, Wirt Co., W. Va.; Burning Springs, on the Niagara river below the Cataract; and Petrolia, Enniskillen district, Canada West. These points are certainly widely enough removed to make the series comprehensive from a geological standpoint. The analyses do not appear to have been complete ones, as M. Fonqué determined the exact amounts of only a few of the constituents. In general, the gases were composed of

members of the marsh-gas series of hydrocarbons. Thus the gas from Pioneer Run he found to have essentially the composition of propyl hydride ($C_3 H_8$), with small quantities of carbonic acid and of nitrogen; the Fredonia gas appeared to be a mixture of marsh-gas (CH_4) and ethyl hydride ($C_2 H_6$), with a small quantity of carbonic acid and 1.55 per cent. of nitrogen; the Rogers' Gulch gas was CH_4 almost exclusively, with 15.86 per cent. of carbonic acid, and a small quantity of nitrogen; the Burning Springs gas almost pure CH_4 with a little CO_2; the Petrolia gas a mixture of marsh-gas (CH_4) and ethyl hydride ($C_2 H_6$), with a small amount of carbonic acid.

However, in some cases the composition as given above was only apparent, as in the case of the Pioneer Run gas, for on passing the gas through alcohol a part was absorbed, which was afterwards shown to be butyl hydride ($C_4 H_{10}$), while the part unabsorbed showed nearly the composition of marsh gas (CH_4). It was evident, therefore, that what appeared to be propyl hydride ($C_3 H_8$) was in reality a mixture of marsh-gas (CH_4) and butyl hydride ($C_4 H_{10}$).

In 1870, Prof. Henry Wurtz made an analysis of the gas from a well in West Bloomfield, N. Y. The results of this analysis are found in *Silliman's Journal* (2) *XLIX., p.* 336. He found:

Marsh-gas	82.41
Carbonic acid	10.11
Nitrogen	4.31
Oxygen	0.23
Illuminating hydrocarbons	2.94
	100.00

The specific gravity of the gas was .693.

The methods of analysis were not the usual ones of gas-analysis, but some new absorption methods devised by himself in conjunction with Prof. B. Silliman. This, I believe, is the extent of the published information on the subject.

The gases which I collected and analyzed were:

First, the gas of the Burns Well in Butler County; secondly, that of the Harvey Well in the same county; thirdly, that from the Leechburg Well across the Kiskeminitis river from Leechburg, in Westmoreland County and fourthly, the gas bubbling from a spring at Cherry Tree in Indiana County. As the results of Fonqué just given had rendered the presence of higher members of the marsh-gas series than CH_4 probable, at two of these wells, I made, in addition, absorption tests with absolute alcohol and with bromine, hoping to prove qualitatively the presence or absence of these higher hydrocarbons as well as those of the ethylene series. For while marsh-gas itself is insoluble in absolute alcohol, ethyl hydride ($C_2 H_6$) is dissolved to the extent of $1\frac{1}{2}$ volumes, propyl hydride ($C_3 H_8$) to the extent of 6 volumes, and butyl hydride ($C_4 H_{10}$) to the extent of 18 volumes in one volume of the alcohol. A pas-

sage of the natural gas for 15 or 20 minutes, therefore, should saturate the alcohol with such of these hydrocarbons as might be present. The bromine absorption test was made in order to ascertain whether any ethylene or butylene dibromide would be formed by the passage of gas.

The gases tested in this way were the gas from the Burns Well and gas from the Leechburg Well. The bottles containing the alcohol, having been tightly stoppered and sealed at the time, were afterwards examined in the Laboratory. The Burns Well gas was first examined. The alcohol through which the gas had been passed was transferred to a small flask, and enough additional alcohol was added to completely fill the flask. A cork perforated and carrying a delivery tube was then fitted to it so that the excess of alcohol filled this tube also.

The flask was now heated, and the gas given off was collected in a eudiometer tube over warm water. I obtained thus some 150 cubic centimeters of gas. The operation was pushed until only alcohol vapor was given off, which was absorbed by the water. To the gas in the eudiometer I then added rapidly an equal volume of chlorine, and allowed it to stand exposed to diffused sunlight. Oily drops formed at once, while the volume of the gas contracted until it occupied only about one-half of the first volume.

This showed the probable formation of ethyl chloride ($C_2 H_5 Cl$) which is gaseous at temperatures over 12°C, and of either propyl chloride ($C_3 H_7 Cl$) which is liquid at temperatures under 52° C, or of butyl chloride ($C_4 H_9 Cl$) which is liquid at temperatures under 77.6° C. On inverting and applying a flame to the gas in the eudiometer, it was found to be inflammable, burning with the greenish flame characteristic of ethyl chloride. The water upon which the oily drops had collected, was put in a small flask, and an attempt was made to separate them by distillation. This was however, unsatisfactory, as there could only have been small quantities of either propyl chloride or butyl chloride. The water in the eudiometer tube reacted acid from the H Cl formed.

The result of these tests may therefore be summed up as showing the certain presence in the gas of ethyl hydride ($C_2 H_6$) and the probable presence of either $C_3 H_8$ or $C_4 H_{10}$.

The qualitative examination of the Leechburg gas was made in the same way. I obtained here only about 100 cubic centimeters of gas on heating the alcohol. On mixing with chlorine a contraction of about one-third took place. The inflammability of the residual gas and the formation of oily drops gave the same indications as with the other gas.

The other qualitative tests were with bromine. This had been tightly bottled and sealed up. The bromine from the test with the Burns gas was then placed in a porcelain dish and water added. Pure sodic hydrate was added to neutralize the excess of bromine. The sodium bromide formed dissolved at once in the water. There remained no trace of oily drops such as would be caused by the bromides of the olefine series of hydrocarbons. The sodium bromide was afterwards crystallized out perfectly pure. The test was therefore entirely negative in its results.

On examining the bromine used for absorption with the Leechburg gas, there was apparently a slight layer upon the surface of the bromine, which might have been ethylene bromide. On neutralizing the excess of bromine, however, no distinct evidence could be had of the presence of the bromide, so that the result was left uncertain.

The quantitative analyses were next made. In these the carbonic acid, carbonic oxide, illuminating hydrocarbons, and free oxygen were tested for and when present removed by suitable absorption re-agents, while the hydrogen, marsh-gas and ethyl hydride were determined by the eudiometer analysis. Any nitrogen present remains over and is estimated at the conclusion of the analysis.

Burns Well Gas (average of two analyses).

Carbonic Acid	.34
Carbonic oxide	trace
Illuminating hydrocarbons ($C^n H_{2n}$)	——
Hydrogen	6.10
Marsh-gas (CH_4)	75.44
Ethyl-hydride ($C_2 H_6$)	18.12
Propyl-hydride ($C_3 H_8$)	trace
Oxygen	——
Nitrogen	——
	100.00

Leechburg Gas (average of two analyses).

Carbonic acid	.35
Carbonic oxide	.26
Illuminating hydrocarbons ($C_n H_{2n}$)	.56
Hydrogen	4.79
Marsh-gas	89.65
Ethyl-hydride	4.39
Propyl-hydride	trace
Oxygen	——
Nitrogen	——
	100.00

Harvey Well Gas.

Carbonic acid	.66
Carbonic oxide	trace
Illuminating hydrocarbons	——
Hydrogen	13.50
Marsh-gas	80.11
Ethyl-hydride	5.72
Propyl-hydride	trace
Oxygen	——
Nitrogen	——
	99.99

Cherry Tree Gas (average of two analyses).

Carbonic acid	2.28
Carbonic oxide	——
Illuminating hydrocarbons	——
Hydrogen	22.50
Marsh-gas	60.27
Ethyl-hydride	6.80
Oxygen	.83
Nitrogen	7.32
	100.00

It will be seen that the first three of the gases just analyzed are very similar in composition, while the gas escaping from the spring at Cherry Tree differs very considerably from the others. The larger amount of carbonic acid and the presence of free oxygen and nitrogen are the chief points which distinguish it. It is only natural, however, that a gas escaping from fresh spring water should contain these gases, as they are the gases usually dissolved in spring water. As to the other constituents of these gases, hydrogen, marsh-gas, and ethyl hydride are the most important ones. In the case of two of the gases, the Burns gas and the Leechburg gas, qualitative tests directly proved the presence of this last constituent. The other two ingredients can also be proved to be there by the application of Bunsen's formulas to the result of the eudiometric analysis. Thus, as the volume of gas taken for the eudiometric analysis can contain only hydrogen, hydrocarbons of the marsh-gas series and nitrogen, we need for our formulas four known values; the volume taken, the contraction after passage of the spark, the carbonic acid produced by the combustion and the free nitrogen in the sample of gas taken.

In the three gases first analyzed this last constituent proved to be absent, so that we had only three values, and could form only three equations, containing three unknown quantities. These equations were:

$$x + y + z = V. \quad (1).$$
$$y + 2z = C. \quad (2).$$
$$3x + 2y + \frac{5}{2z} = A. \quad (3).$$

where V equals the volume taken, C the carbonic acid formed, and A the absorption or contraction, consequent upon the explosion, where also x was taken as hydrogen (H), y was taken as marsh-gas (CH_4), and z was taken as ethyl-hydride (C_2H_6). When in these equations were substituted the found values of C and A, I got plus values for x, y, and z. On the other hand, if I assumed two constituents only, x as hydrogen and y as marsh-gas, the y was made equal to C at once, which was obviously incorrect, and would have given a minus value to x. If again, I assumed x to be equal to CH_4, and y equal to C_2H_6, I got false values for x and y. One other assumption only was open to me, that was to take x as hydrogen, y as marsh-gas (CH_4), and z as propyl hydride (C_3H_8). This would have given

plus values for x, y, and z, but the previous qualitative tests had shown conclusively the presence of $C_2 H_6$.

I found, however, unexpectedly in Fonqué's memoir the strongest confirmation of my interpretation of my results. Using the three equations that I have given above, he finds that when x, y, and z represent three successive members of the marsh-gas series, the equations are as follows:

$$x + y + z = V. \quad (1).$$
$$x + 2y + 3z = C. \quad (2).$$
$$2x + \frac{5}{2y} + 3z = A. \quad (3).$$

from which can be deduced as a fourth equation.

$$2A - 3V = C. \quad (4).$$

In other words, when an eudiometric analysis of a mixture of hydrocarbons of the marsh-gas series is made, the carbonic acid formed is equal to twice the contraction, minus three times the volume of gas taken.

He says, therefore, (*Compt. rendus.* LXVII. p. 1048) when the marsh-gas hydrocarbons are mixed with free hydrogen, this fourth equation is not realized. I did not find it realized in any of my analyses. Thus in the analyses of the Burns Well gas, I had the following figures:

	I.	II.
Gas taken	32.74	24.49
Contraction	70.4	52.75
CO_2 absorbed	36.6	27.5

If we substituted the values of C and V as found, in the formula $2A = C + 3V$, we get, for the first, $36.6 + 98.22 = 134.82$, of which the half is 67.41. But the observed contraction is 70.4, or 2.99 greater than that demanded by Fongué's formula for the marsh-gas hydrocarbons. So for the second we get $27.5 + 73.47 = 100.97$, of which the half is 50.485, while the observed contraction is 52.75.

If now we turn to to the formulas first stated by me, we find the explanation in the third equation where we have $3x$, assuming x to be hydrogen; and in the second equation where we have $0x$, assuming x to be hydrogen.

I have not been able as yet to make any experimental determinations of the specific gravity of these gases, but have the material reserved, and expect to do so. The specific gravities as calculated from the analyses given, are as follows:

	Sp. gr.
Burns Well gas	.6148

Mr. Lesley mentioned that Mr. Hall had found three casts of an *Orthis* of the Trenton (Bala) Limestone in a subangular fragment among the moraine (?) matter cut into for a drain in front of the University buildings in West Philadelphia.

Mr. McArthur presented through Mr. Walter nine photographs of models of ornaments for the Public Buildings.

Pending nomination No. 791 and new nomination No. 792 were read.

The minutes of the last meeting of the Board of Officers and Council were read.

Mr. Blodget, from the Committee on the Progress of Science Exhibition at the Centennial, reported that his Committee had met, and would act with a committee appointed by the Acad. Nat. Science, Phila. (Dr. Le Conte, Mr. C. E. Smith, Mr. W. Vaux), and he read a paper expressing the views of the joint committee, and explained that a room 24′ by 48′ in the southeast end of the Main Building, up-stairs, had been appropriated by the Commission to their use, and there was good reason to believe that learned Societies would respond cordially enough to fill this room.

Prof. Campbell disclaimed for the Commission all responsibility, except for guaranteeing the right of placing whatever it saw fit in this room by the joint committee.

Prof. Fraley said that an application would be made to the Society for permission to exhibit its Elliot Bible.

There being no other business, the meeting adjourned.

Stated Meeting, March 3, 1876.

Present, 10 members.

Mr. Eli K. Price in the Chair.

Letters of acknowledgment were received from Dr. Jacob Bigelow (95); Silliman's Journal (95); the Smithsonian Institution (95); the Emden Society (92); and the Physical Society in Berlin (87 to 91; xiv, 3, xi, 1).

Letters of envoy was received from the Coast Survey; from the Physical Society in Berlin; and from the

Royal Irish Society, requesting missing Parts 2 of Vol. iii, 1

of xiii, and 2 of xiv, to complete the set, which was on motion so ordered; also from

The K. Leop. Car. Deutsch Akademie der Naturforscher requesting exchanges, having only Trans. Vol. I. O. S. 1769. The request was referred to the Publication Committee with power to act; also from

A. J. Holman & Co., 930 Arch street, tendering a request for the loan of the Elliot Bible in the Library of the Society. The request was referred to the Library Committee with power to act.

The request of the Philadelphia College of Pharmacy for No. 93 to complete their set, was granted.

Donations for the Library were received from the Geological Institute at Vienna; the Leop. Car. German Academy at Dresden; the Prussian Academy, and Horticultural Society, and Herr Schwalbe of Berlin; the Society at Emden; the Belgian Academy; the Geographical Society and Reviews in Paris; the R. Astronomical and Geographical Societies in London; the Natural History Society at New Castle; the R. Irish Academy; the Boston Society N. H; the Cambridge Museum C. Z.; Silliman's Journal; American Chemist; Dr. J. S. Newberry; Poughkeepsie Society of Natural Sciences (ordered to be placed on the list to receive the Proceedings); Journal of Pharmacy; Penn Monthly; U. S. Department of the Interior; U. S. Coast Survey; Georgia Historical Society, and the San Francisco Mercantile Library Association.

Mr. Wootten communicated, through Dr. Cresson, a paper on the successful use of anthracite coal-dirt on a new form of locomotive, drawing coal trains, on the Reading Railway, and described on the blackboard the form of fire-box floor, draft tuyeres, absence of exhaust and smoke stack, length of flame, &c., &c.

Pending nominations Nos. 792, 793 were read, and the meeting was adjourned.

A Combination of Apparatus by which ordinary Anthracite Coal-waste, from the Dirt-banks at the Mines, can be successfully and profitably burned in the Furnaces of Stationary and Locomotive Boilers.

By John E. Wootten, Reading, Pa.

(*Read before the American Philosophical Society, March* 3, 1876.)

Prominent and peculiar features in the landscape of the Coal Mining Regions are the enormous heaps of black and apparently useless material collected near the outlet of each mine. The nature of this material can be best understood by a brief consideration of the source from which it comes.

The coal measures are made up of veins of coal of varying thicknesses and constitution. The coal of which they are composed, especially in the thicker veins, has mixed with it layers of slate, sometimes in mass, at other times finely laminated and disseminated throughout the seam.

As the coal is found in beds interstratified with rocky formation, it is subject to similar accidents as are the rocks themselves when disturbed by convulsions of nature; therefore when portions of a vein are crushed and rendered unfit for use as marketable fuel, it must, notwithstanding its unfitness, be removed from the mine to permit access to the more valuable coal.

Seams of considerable thickness are usually divided into separate beds of varying thickness, by deposits of slate, which impurity must be removed in the preparation of the coal for the market; and the same seam may furnish several qualities of coal.

The great heaps of material to which we have referred, are thus the results of the various operations of mining and preparation of the coal for market. They contain therefore, in addition to the earthy matter, slate and rock already mentioned, a large portion of the purest coal taken from the colliery, not only that which is crumbled into small fragments during the operation of mining, but also that, which having passed through the breaking rollers is crushed into particles of too small size to be merchantable, and is for that reason consigned to the dirt heap. The last named contribution to the heap constitutes from twelve to fifteen per cent. of all the good coal that is mined, and is the result of the wasteful method which is employed to reduce the large lumps to the uniform sizes required by the demands of the trade.

Some of these heaps are the accumulations of half a century, and have been exposed during their formation to the action of the weather and such atmospheric influences as have lessened their value for heating purposes by loss of carbon and saturation with moisture.

We have therefore, in dealing with these masses as fuel, to overcome the difficulties consequent upon their containing a very large amount of incombustible matter, all of the elements for the ready production of clinker and incapability for producing an active or vigorous fire in the ordinary furnace.

To consume this material with useful effect, it is necessary either to sub-

ject it to a process that shall form it into masses of moderate dimensions, so that when thrown into a furnace, interstices may be left to allow of access of air to the surface of the lumps, in the same manner as is the case with ordinary lump coal; or else special means must be provided to retain and consume it in the furnace; and peculiar appliances be made use of to insure the passage of air through the fire-bed and its proper contact with the fuel. In either case provision must be made as far as possible for the prevention of the formation of large masses of clinker and the disposal of the ash.

The first method referred to, that of forming the coal waste into lumps of proper dimensions, by the admixture of clay or bituminous matter, or other cohesive material, can only be profitably employed when the cost of the operation is less than that of mining and preparing coal at the colliery.

Heretofore the largest proportion of the coal mined was from above the water level, and the comparatively low rate at which such coal was mined prevented the successful application of any processes for agglomeration.

As the coal above the water level is being exhausted and deep mining has become necessary, the increased cost has directed attention to the utilization of the waste coal under consideration.

A large investment of capital in machinery may bring the cost of manipulation below that of mining; but it is not likely that the run of the waste coal heap can be utilized by any such process, as it contains so large a proportion of foreign and incombustible material.

It is obvious that if the coal in its minutely sub-divided state can be advantageously consumed by means of any process or device which shall be moderately simple in its construction and no more expensive of maintenance, than an ordinary boiler furnace, the problem of utilization of coal waste will have been solved, and a very considerable economy in cost of fuel attained.

With this object in view, a method of consuming the material in ques tion has been devised and may be described as follows:

Air is injected into a closed ash-pan by means of a steam jet passing through one or more tubes. These tubes should be cylindrical, when volume of air without much intensity is sufficient; but when greater intensity is desired, as in the furnace of a locomotive, they should each be formed of two frustrums of cones, united at their smaller diameters; the proportions of the larger and smaller diameters varying with the degree of intensity of blast required.

The mingled air and vapor pass through a perforated fire-bed into the fuel in the furnace, and are thus evenly distributed through the fire, the fuel being spread over the fire-bed to a depth of about three inches.

The fuel upon the grate is gently lifted by the blast from over the perforations, the finer particles floating upon the current until the carbon is consumed; a large proportion of the ash passing off in a finely divided state, with the draft out of the stack.

The decomposition of the vapor in passing through the fire, results in

the production of hydrogen and hydrocarbon gases, in addition to the carbonic oxide usually formed.

The blue flame of carbonic oxide is to a great extent replaced by that of the hydrocarbons and hydrogen. The combustion of this fuel resembling that of bituminous rather than anthracite coal; the flame extending occasionally to a distance of over twenty feet, instead of as many inches, as is the case in the combustion of carbonic oxide gas from ordinary anthracite coal burned in the usual manner.

The decomposition of the vapor causes a considerable reduction of temperature in the furnace. This cooling effect in the furnace does not, however, result in a loss of heat, as the re-combustion of the hydrogen derived from the decomposition of the vapor yields as much heat as was absorbed in its formation.

To insure the rapid and complete combustion of the fuel, and prevent the formation of solid masses of clinker, it should be repeatedly stirred upon the fire bed with a rabble-shaped tool. This stirring process is an important element in the successful use of the fuel under consideration, as it serves to relieve the fire from the finely divided ash, which is thus exposed to and carried by the draught over the bridge-wall or through the flues of the boiler into the stack.

The perforated fire-bed forms an essential feature of the device, inasmuch as the loss of fuel through the grate during the stirring process is thereby greatly diminished, the average loss being less than two per cent. of the coal put into the furnace, whilst the weight of the fuel used for steam generation and stationary and locomotive boilers, is but slightly in excess of that which would be required of standard marketable sizes of prepared coal when burned in the same furnace with the ordinary bar grate in the usual manner.

The perforations in the plate of the fire-bed, are made from three-eighths to three-fourths of an inch in diameter, and from two to three inches from centre to centre.

Wrought iron is preferred for making the perforated fire-beds, as that material admits of the use of a much thinner plate than cast iron, and consequently there is less liability to obstruction of the air passages.

The exhaust blast of the locomotive is altogether unsuited to the consumption of the fuel under consideration, as by reason of its impulsive and vigorous lifting action, it is impossible to maintain the fire in the comparatively quiescent condition requisite for favorable results with anthracite coal dirt.

The usual method of urging the fire by means of the exhaust steam has therefore been entirely dispensed with, and instead of discharging the exhaust steam directly into the atmosphere, its heat is absorbed as far as possible, by passing it through tubular feed water heaters before allowing it to escape.

By this means, feed water is introduced to the boiler at a temperature in excess of 212° F.

A locomotive engine, using coal dirt exclusively for fuel, has recently been engaged in hauling coal trains over the Philadelphia and Reading Railroad, generating steam freely without the use of any portion of the exhaust steam as a draught-promoting agent, the substitute being a continuous supply of air and vapor, introduced into a closed ash-pan as above described, aided by very small jets of live steam in the chimney for the purpose of facilitating the passage upwards of the products of combustion.

These results obtained from many boilers now using the apparatus described, show that the hitherto neglected and apparently valueless material, known as coal dirt, can be profitably used for generating steam, and that hereafter it must be regarded as a fuel of great value.

Stated Meeting, March 17, 1876.

Present 16 members.

Dr. Bridges in the Chair.

A letter acknowledging the receipt of Trans. V. and Proc. 94, was received from the Boston Society of Natural History.

Donations for the Library were received from the Bureau of Mines at Victoria, the Society of Physical Science at Bordeaux, the Revue Politique, Canadian Naturalist, Boston S. N. H., American Antiquarian Society, Bedford Library, Astor Library, Franklin Institute, Medical News, Prison Discipline Association, Geological Survey of Pennsylvania, Geological Survey of Ohio, and President Allen.

Prof. Houston communicated again his views respecting the so-called new force, and in reference to certain strictures which have appeared in print, since his former communication. He described the results of experiments proving a polar condition of the force, and demonstrating the impossibility of its being anything but electricity under stratical tension.

Mr. Eli K. Price continued the communication of his views on the Glacial Epoch, so-called, arguing against a general polar outspread of ice, and for the explanation of all drift phenomena on the theory of iceberg distribution.

Prof. Chase exhibited diagrams representing certain mathematical and astronomical relationships of length, orbital movement and planetary distance, which he stated and described, including in his subject matter of discussion the possible influence of the meteor-belts.

Pending nominations Nos. 792, 793, and new nominations Nos. 794 to 802 were read.

On motion, the Committee appointed at a previous meeting to consider the expediency of an exhibition of the Progress of Science in the last hundred years, was discharged from further consideration of the subject.

A request by letter from Mr. Etting that the Society permit the exhibition of its original draft of the Declaration of Independence by the city in the Museum of the City Hall, was, on motion, referred to the Curators to report.

And the meeting was adjourned.

ON SOME DISPUTED POINTS IN PHYSIOLOGICAL OPTICS.

By Henry Hartshorne.

(*Read before the American Philosophical Society, April* 21, 1876.)

I. On the Theory of Erect Vision, with Inverted Retinal Images.

As it has been ascertained, by both mathematical and physical demonstration, that the image of every object seen must be inverted upon each retina, several explanations have been offered for the correspondence of our sight with the actual position of visible things. The most prominent views advanced are the following :—1. That we do see everything inverted, but that the correction has been obtained, and has become habitual and momentary, through *experience;* 2, that the reversal of all images is effected by the crossing of the filaments of the *optic nerves;* so that, e. g., all the filaments from the upper part of the retina go to the lower part of the optic ganglia at the base of the brain, and *vice-versa;* 3, that we do not mentally regard the image or picture *upon the retina* at all, but look *from* the retina, *at the object;* or, as one authority upon the subject prefers to express it, "the local change excited in the retina must be conveyed to the optic nerve, communicated to the brain, and again, in an inverted direction, projected outward; through this double inversion the projected image corresponds to

the object, and we therefore say we see the object when only the projected retinal image is before our eyes."

Against the hypothesis of the correction of inverse vision by *experience*, we have, first, the clear and, so to speak, imperative testimony of every one's consciousness; secondly, the very satisfactory observations and experiments of Spalding and others, upon newly hatched chickens and new-born pigs. The chicken just out of its shell, or one, after hatching, hooded for a day or two and then allowed to see, will *at once* locate an object brought near it (as an edible seed or grain), seizing it accurately with its bill; and will, also, *at once* run in answer to the cluck of the hen, almost always in a *direct line*. Similar facts, precisely, have been observed with pigs immediately after their birth. Thus, *in these animals*, the non-necessity of experience, even for the visual measurement of distances at short range, is proved; much more then must it be impossible that experience should be needed to set things upright, they being inverted according to actual vision. While analogy here only affords a probability as to what is true with regard to human sight, that probability is nevertheless very strong indeed: not that correct visual impressions in all respects are *congenital* with man, as our observation of infants does not seem to show; but that at least the simpler elements of vision attend in their development the maturity of the eye as an organ; and that among these elements, the sight of objects as not inverted must be one of the simplest. If it be said that the readiness for use of the senses and faculties of some new-born animals is a result of hereditary transmission, *a race-experience*, accumulated through long periods of time, I have nothing to say against this as, in itself, a not improbable hypothesis, in regard to the mode of *origin* of such endowments. But the idea of experience which is involved in the view just above-mentioned, is quite different from this last. Experimentally acquired corrections of positive sensory perceptions never go so far as to *annul* the perception which has to be corrected, to such an extent that the *process* of correction *cannot be ascertained by consciousness.*

On the hypothesis that the inversion of the retinal images is effected by a uniform decussation of the optic nerve-filaments, it is needful to remark only three things: 1, that this must be a pure assumption, no such mode or plan of arrangement of the filaments of the optic nerves being anatomically discoverable; indeed, a much more general and intricate plan of exchange of filaments, between eye and eye, optic ganglion and its fellow, and all the parts of the two eyes and the two ganglia, having been proved to exist; 2, that such an explanation is opposed to all the analogies of nerve-distribution, in regard to the localization of impressions; the relative *position* of the nerve-*trunk* or its filaments, never affecting much if at all, our perception of the locality of any sensation; all notions of locality or direction, under normal circumstances, being obtained by means of, and *at* the *organ*, not the transmitting or communicating nerve, of sense which is concerned; 3, that the same reversal of position of the image or picture on the retina produced by rays from an object seen, must occur *horizontally* as well

as vertically, the rays from the right side of the object crossing those from the left side as they enter the eye, so that (as in a mirror) what is right side in the object is left side in the retinal picture, and conversely; the difficulty of the anatomical explanation referred to being at least doubled by this *complication* of reversal.

It remains here for me to assert my adherence to the opinion, which is generally growing in favor with physiologists, that much the nearest approach to a solution of the problem of upright vision with inverted retinal images must be expressed in terms essentially conforming to the 3d of the hypotheses above briefly stated. The phraseology used in the passage which I before quoted, making "an image projected outward" that which (not the object) is seen, does not appear to me to be necessary, although it has convenience in describing the analysis of some of the phenomena of vision.

That which it is especially my design to remark upon in this connection is, the clear illustration furnished by our visual experience, and sustained by that of our other senses, of the *externality* belonging to, and inherent in, all sense-perceptions. *Direction* of sound is apprehended , even with only one ear open to receive it; the precise *rationale* of our recognition of the direction of sounds not yet being agreed upon amongst physiologists. I believe that it is obtained by the exquisite sensibility of the orifice, and parts near it, of the external meatus of the ear; a sensibility intermediate between auditory and tactile sense; a kind of gradation existing here, which, there is reason to think, has many illustrations in the partially dfferentiated sense-organs of lower animals. So, also, we judge, in case of touch, of the *direction* from which anything comes, a ball, for instance, striking the hand, by reversing, as it were, the central axis of predominance of the impressions made; which is analogous to the ocular visual axes, whose correspondence gives us single object-perception in sight.

II. On Extuition as a New Term in Psychology.

My reason for dwelling at some length upon the above points of statement is, that I conceive it to be of consequence in psychology (which in regard to sense-perception, especially, is inseparable from physiology), that a more distinct apprehension should exist than has hitherto prevailed, as to the essential, original and inherent, *externality* of the report made to our consciousness by *all* our organs of sense, of the impressions made upon them. In the but partially inductive study of psychology of past times, to which the term "metaphysics" may be, without disrespect, applied, the idea of the Cartesian formula, "Cogito, ergo sum," has been accepted in too exclusive or monopolizing a manner. This was, and is, a deduction occurring in the self-consciousness of the mature philosopher. Could a child, a year old, give its mental experience, so as to define its way of arriving at the knowledge of the *ego*, of its own personal existence and identity, it would doubtless say, "*Percipio, ergo sum.*"

Not uncommonly, authors on psychology assert, in effect, and sometimes

in their very words, that sensation is in the first place always *intuitive;* the process of perception then following, by which a reference of the quasi-subjective impression of consciousness is made, to an external cause. Now I believe that we are justified in denying the correctness of such language; and refusing to admit that sensation is *per se* intuitive, in any proper sense of that word. *Subjective* it may be, just in so far as it is an affection of the subject whose organs of sense (and through them the consciousness) are impressed. But I would insist that the affection of consciousness in sense-perception, nay, in primary *sensation,* is distinctly *objective* in its nature; at least to the extent that the bodily organ affected (not the central *ego* of the metaphysician, nor the brain which receives the terminations of the nerves of sense) is always, to us, the *immediate seat* of sensory cognition; while, at least in the cases of sight and hearing, *externality* belongs, by the law of our constitution, to sense-perception, in its primary nature; not needing a secondary process to attach the inference of outwardness to it. We cannot explain this farther than to say that it is the fact or law of sense-cognition, according to our bodily and mental constitution; but this is true of any and every other view of the subject which may be taken, whether old or new; and the legitimate aim of psychological science must be, as with any other science, to find by observation, experiment and careful induction, *what are* the facts and laws of mind, in all its actual relations. I believe that it may promote definiteness of thought upon this subject, to introduce a new term into psychology; namely, *extuition.* While the word intuition is, as familiarly used, well adapted to denote the reflective process, by which *ideas of reason* are obtained, it appears to be altogether misapplied when the same word is made (as by some leading authors it is) to indicate also the mental affection or act occurring in *sensation.* The importance, in my judgment, of this addition to the language of philosophy, of so explicit a term as extuition, conveying a meaning for which there is now actually no existing word, and scarcely a simple English phrase, is the *raison d'être* of the present communication. Word-making has always against it a strong presumption of uselessness, if not of impropriety; but in this case, the presumption seems to me to be over-ruled by a real necessity of thought and of expression. By means of the thought which is intended to be thus expressed, a satisfactory antithesis, and (as it is *inductive*) a tenable refutation, of Berkleyan idealism may be obtained; through the aid (too often overlooked by psychologists) of some of the most clearly demonstrable facts of physiology. Our sensorial consciousness affirms the reality and externality of the objective world, no less *simply, directly* and *positively,* than our reflective consciousness affirms our subjective being.

III. On Ocular Color-Spectra and their Causation.

In order to introduce a few observations which, if not novel, have at all events been but seldom noticed, and to bring forward what I believe to be a new explanation of a remarkable group of optical phenomena, it is need-

ful to refer to some facts familiar to most of those who have given attention to physiological optics.

When the eyes have been directed for a short time to a *bright* object, as a piece of polished silver, and they are then turned towards a white wall or other light surface, a *dark* spot or figure, having the outline of the bright object first seen, is beheld upon the white or light surface. Or if, on the contrary, a *dark* body, as an inkstand, for instance, be looked upon steadily for awhile, on turning the eyes toward a light ground, a brilliant *white* corresponding figure is seen. These are called *negative spectra*. If, now, instead, we look fixedly at a *colored* object, and afterwards turn the eyes to a white ground, or, if the colored body be *upon a white surface* and, after a time, this body be *removed*, we we will see, in either case, a spectrum having the *color complementary* to that of the object beheld. These are, also, commonly called negative spectra; the expression *complementary color-spectra* will designate them more accurately, without regard to theory.

It has been noticed that, near sunset, the rays of the sun passing through an orange-colored cloud cast bluish shadows; and likewise, the shadows of of objects seen behind red curtains are apt to be green. If the light either of the sun or of a strong artificial light be made to pass through a pane of colored glass, so as to fall upon a white ground, and a slender object, as a rod, or the hand, intercepts the colored light, the shadow thrown has the *complementary* color to that of the transmitting pane. Red glass will thus throw green shadows, green glass red, orange glass blue, &c. If we look at the shadow, so thrown, through a tube, so that it alone is seen, it is perceived as a shadow without color. Also, if the same shadow falls upon a *black* surface, no shadow appears.

The above mentioned facts have all been repeatedly observed; and but one explanation, so far as I can ascertain, has, as yet, been proposed for them.* It is that suggested by Dr. Thomas Young, and accepted by Helmholtz. Young's theory of colors, being the application to vision of Johannes Müller's general theory of special sensation (as depending upon the character of the sensory *organ* more than on that of the external cause), asserted the existence of different susceptibilities to color rays in different portions of the retina; or among the different optic nerve-filaments. With our present knowledge of the minute structure and relative functions of these parts, such special susceptibilities, viz: to red, green and violet light, as Young designated the primary colors, or to red, yellow and blue, as they are more commonly named, may be referred to the posterior layer of the retina; the layer of *rods and cones* of Jacob and Max Schultze. Helmholtz adopts this theory of Young, as the only one giving any clue at all toward solving the

*Since this was written, I have read, in Lardner's treatise on Optics, a brief statement of Plateau's theory, of an "oscillatory movement" of the whole retina, when affected with light, in connection with what he designates as a resistance of the retina to the action of any color, and a tendency to resume its ordinary condition, with a more or less intense force. There seems to be extremely little evidence in favor of this theory; and it has apparently fallen out of view in later works.

problem of the vision of colors; which, as the great German physicist declares, had baffled not only the powerful mind of the poet-philosopher Gœthe, but many able students of physics and physiology besides.

There seems to be no good reason for hesitating to accept this theory, of the special responsiveness of certain retinal nerve-elements to particular luminous rays. Helmholtz supports it by at least one striking fact in the comparative histology of the eye; viz: that in a number of birds and reptiles, many of the rods of the retina contain, at their ends which are turned towards the light, minute drops of colored oil; in some red, in others yellow; while others of the rods in the same eyes are entirely colorless. Also, he refers to the analogy of the *organs of Corti* in the cochlea of the ear; which are supposed, with considerable reason, to vibrate in accordance with particular notes of sound; and, also, to some remarkable external filamentous appendages to the organ of hearing in certain marine crustaceans; which Hensen, of Kiel, has shown to be set in motion, some by one, and some by other kinds of sonorous vibration. These last facts recall the admirable and similar series of experiments of Prof. Mayer, upon the vibrations of the antennæ of mosquitoes. I believe that there is much importance in this general theory of undulatory consonance, and of special responsiveness, of the minute elements of the organs of sense. It is in the *manner* of the *application* of this theory by Helmholtz, and, with him, by all other late physiological writers known to me, to the explanation of *negative* and *complementary color spectra*, and *color shadows*, that it appears to me a deficiency exists, fatal to the reception of that current explanation; and suggesting, if not proving, an almost or quite contrary view of the same facts.

The application I here mean to object to, is this: that negative and complementary color spectra and color shadows are all explained by partial or local *fatigue* of the retina, under impressions of light, so that the part of the retina impressed, e. g., by a particular color, becomes, through fatigue, less sensitive to the same color, kind, or degree of light; and therefore an impression is, during the time of that fatigue, made upon our visual consciousness only by the opposite or complementary rays; these affecting those parts or elements of the retina which are fresh, not having been wearied by use. According to this, when we look for a time upon a red object, those rods and cones, or nerve-cells, or nerve-filaments (or, as Prof. Draper would have it, portions of the *choroid coat behind* the retina) which are affected by red rays, become exhausted; and so, when we turn toward a white ground, we are, for the time, red-blind; while the *green-seeing* capacity, so to speak, is fresh and vigorous. Thus we see, at that time, only green; or, the complementary color in any other like case. This *fatigue* theory is what I am constrained, notwithstanding the very eminent authorities by whom it has been hitherto supported, to call definitely in question. Let me here mention the observations which first led me to look for a different view of the whole subject of these kindred phenomena.

If a piece of thin white paper, such as is commonly used, on account of

its light weight, for foreign correspondence, be laid over a piece of brightly colored material (paper, silk, flannel, or any other) and then on the latter a small black or dull colored strip or fragment of any kind be laid, under the paper, this *fragment or strip* will appear to be of the color *complementary* to that of the *larger and brighter ground* upon which it is placed. Any color will answer for this experiment; although the effects are most distinct with red and green grounds; tolerably so with bright yellow; least so with blue, purple, and all dark shades. It makes no difference what is the *hue* of the *fragment* or *strip* upon the brighter ground under the paper, so long as it is duller or darker, as well as considerably smaller, than the ground on which it is laid; it will always have the color complementary to that ground. Put, for example, together, under the thin paper, on a bright green ground, strips of blue, red and yellow glass, and one also of black worsted or paper; all of these, seen through the paper, will be, *alike*, distinctly *red*.

Now, on observing these facts, let it be noticed, especially, that the effect produced, the complementary color given, is *instantaneous*. The moment you look at the bright ground with the dull or indifferent strip over it, you *at once* see that strip with the *complementary* color. Lift the paper, and the real hue, or blackness, is seen; replace it, and it becomes again changed as before. There is here *no time for fatigue* of the retina, or of any part of it. Again, if the bright ground have, around it, a *margin* of the paper which is laid over it, that margin will have a faint but distinct *flush* of the complementary color. If the bright ground be *moved* to and fro, this overflush of color may be, sometimes beautifully, shown, following the line or edge of the moving mass of strong color; and most distinct near the edge. This effect, also, is instantaneous; there is no opportunity for *fatigue* in any way to explain it.

Finding then, this "fatigue" theory quite insufficient for these facts, attention to the phenomena of *color-shadows* above referred to, has impressed me with a belief that the same theory falls short with them also. They are, likewise, immediate, momentary effects. You look at the white ground, bathed in colored light, which light is partly intercepted by a narrow opaque object; and *at once* you see the shadow of the latter, having the complementary color; there is no possible time for fatigue, or for loss of any portion of the retinal sensibility.

Consideration may next be in place, upon a remark of Helmholtz,* which, though only parenthetically made by him, has very considerable importance. Bright objects, as flames, or the sun, when looked at, give subsequent spectral effects unlike those described as negative. They are, indeed, for a time at least, *positive* spectra. Helmholtz speaks, moreover, of from *half a minute to five minutes'* contemplation of a bright or colored object to produce the *ordinary* negative or complementary color spectrum by looking upon a white ground. I have found from *five to ten seconds* ample, with a kerosene students' lamp; and less time still, with strong sunlight.

*Popular Lectures, transl., 1873.

My experiments with sun-spectra, designed for the purpose of examining more particularly the above facts parenthetically mentioned by Helmholtz, were as follows: At about three o'clock on the afternoon of a clear day I held between my eyes and the sun, a pane of colored glass; using, at intervals, successively, four colors; blue, green, red and orange. After a few seconds, I turned my eyes from the glass upon a white-washed wall. In each case, a strong complementary (so-called negative) color spectrum was seen upon the wall; but, on *closing* my eyes, an almost equally intense *positive* spectrum, having, that is, the *same* color as the stained glass just looked through, appeared. Opening my eyes, the *complementary* spectrum returned; again closing them, the *positive* one; and so on, for half a dozen or a dozen times in succession. A member of my family, and, on another occasion, Prof. E. J. Houston, repeated this observation, with the same results; and I also did so, with entire success, with a magnesium light, at night. These experiments seem to me quite fatal to the supposition that retinal fatigue can account for any class of spectra such as have been above considered; for, if ordinary luminous impressions produce temporary fatigue and loss of sensibility, *stronger* impressions ought to produce still *greater* fatigue and greater loss of sensibility, or partial color-blindness, from that cause; whereas the reverse is the fact. As Helmholtz states, and as Newton found in his famous experiment, which proved dangerous to his sight, very bright objects, such as the sun itself, give *positive* spectra. In Newton's case, after gazing directly at the sun, its image did not pass away from his vision, whichever way he looked, for two or three days. Looking through colored glass, my daughter obtained a solar spectrum which continued for nearly twenty-four hours. In my experiments just mentioned, if it were possible for fatigue to account for the *negative* or complementary spectrum seen with open eyes, what conceivable relation (I certainly think none) can such a cause have, to the *positive* spectrum seen when the eyes were *closed?* If fatigue might *take away*, so to speak, the capacity to see green light when the eyes were *open*, it is against every "law of parsimony" in science to suppose that the same cause could *confer* the capacity to see a green image or spectrum, when the eyes were *shut*.

Another experiment, decisive against the fatigue theory, is one by which a *derived* or *secondary* spectrum may be obtained, as follows: a small square or circle of white paper or muslin is placed in the middle of a large brightly colored ground, red, for instance; and is steadily looked at for from a quarter to half a minute. The white central spot will acquire a tint of the complementary color (green, upon red), increasing in depth with prolonged attention, and especially strong at the nearest point of distinct vision. Then let the eyes be turned to a white ground; there will appear upon it the usual complementary (in the case supposed, green) spectrum, of the ground: but, at the *centre*, there will be also a clear *positive* (red) spectrum, corresponding in place and size, with the *white* central patch. Here, of course, that part of the retina which had received *only white* light, could not, on the fatigue hypothesis, be supposed to lose its sensibility to green,

through exhaustion from special use; while, on the theory which I am about to set forth, the mode of causation of the secondary as well as of the primary spectrum appears quite clear.

It remains, then, to attempt a definite answer to the question, what explanation, conforming with all these facts, can be substituted for that which I have ventured to pronounce unsatisfactory. I make an endeavor in this direction with diffidence; not possessing so precise an acquaintance with physics as might enable me to deal as an expert with so difficult a subject.

Allusion has been made above to four kinds of phenomena; which may be thus briefly named, *en résumé:*

a. Those of ordinary *color spectra*, primary and secondary, seen with moderate light.

b. Color shadows thrown under transmitted light.

c. Over-tints and *complementary shades*, seen through thin paper, on a brightly colored ground.

d. Solar color spectra, positive and complementary by turns, according to whether the eyes are closed, or opened towards a white ground.

These all appear to me to have a common character, and to require an essentially identical explanation.

Take, first, the ordinary color spectra, such as may be obtained with good lamplight. Looking at a red object for a few moments, one then turns the eyes to a white surface; a green spectrum is seen. Why is this? Because, to use the simplest and least hypothetical phraseology, the eyes are *charged, saturated* with red light; and this, having a certain strength, is *neutralized* by the red rays in light reflected from the *white* surface, so that only the *remaining*, complementary, green rays of that light affect the sight. Translating these expressions into language in accordance with the undulatory theory, I would say that, when a brightly colored object is looked at, those rods and cones, or minute retinal nerve-elements, which respond in vibration to the luminous ether-waves of the color reflected to the eyes, are excited to motion thereby; and by "irradiation," or communication of vibrations, all retinal elements which have *the same period of vibration* are made to partake, in some degree, of this movement. Then when, turning from the colored object, *white* light, consisting of all the color-rays or waves together, impinges upon the eyes, those ether-waves of the white light which belong to the color first acting on the retinal nerve-elements, *interfere with*, and for the time relatively diminish or *annul* the special vibrations already produced in the retina; leaving the *other* waves of white light to take effect upon the retinal elements which respond to or "resonate" with them, so that the *complementary* color only is seen.

Very probably *relative diminution*, rather than total arrest, of the special retinal vibrations, is what occurs. All our perceptions of light and color are, to a considerable extent, dependent on the *relative intensity* of light from different sources or of different kinds. When, then, in a beam of white light, a *portion* of certain color rays is, in effect, arrested by previously existing retinal vibrations of the same period, although the *remaining* rays

of the same color might affect the sight *if they were alone*, they are, as it were, overpowered by the unimpeded complementary color-rays. This consideration appears to me to meet an objection to my "interference" theory, suggested by Prof. Houston; derived from the necessary relation of *wave-length* of rays for interference. If only a moiety of the ether-waves of a certain color in a beam of light afford the required opposition of phase in undulation, their arrest or subtraction may yet explain the *relative* lessening of the intensity of that color, so as to cause it to cease to be perceived; the complementary color-rays having twice as great a strength.

When color shadows are produced by intercepting transmitted colored light, the shadows must fall *on a white ground*, or they do not have the color complementary to that which is transmitted. Here, again, the eyes becoming saturated with a certain color, *its* specially responsive nerve-elements in each retina are set in vibration; and, as in the other case, interference occurs between these vibrations and the ether-undulations corresponding with the same color, in the reflected (diffused) white light Let the shadow of the intercepting object fall upon a *black* surface, and the complementary color disappears. Nor will it be seen when only *monochromatic* light is present in the apartment.

Again, the above-described *over-tints* or flushes, and complementary interrupting spots, strips or bands, upon a colored ground seen through thin white paper, depend upon the *white light reflected* by that paper, for their complementary color. If the paper be removed, the actual difference between the ground and the spots, strips or bands laid upon it, will be clearly seen. Replace it, and *at once* a strong contrast re-appears; as before, I hold, resulting from the interference of equivalent vibrations.

Lastly, when a very strong impression is made upon the eyes, as by looking at the sun through a colored glass, the excitement of the nerve-elements is so great as to *persist* in the same manner; producing continued sensation of the same color, when the eyes are closed, for some time. But, when the eyes, in this state, are opened upon a white ground, again the waves of the *same* color-rays in the white light *kill*, as it were, that color in the eyes; or, in other words, arrest, for the time, enough of the existing retinal vibrations to annul their effect in sensation, so that only the remaining (complementary) rays of light are perceived. Bright reflected white light thrown even upon the *closed* eyes will have this effect.

An analogous explanation will suffice for the *secondary* or *derived* spectra, mentioned on a previous page. Looking steadily at a small white spot on a red ground, for example, the white spot becomes green; turning thence to a white ground, a large green spectrum is seen, with a red spot in the centre. The latter I call a secondary spectrum. While looking at the *red ground*, vibration of the *red-resonating* retinal nerve-elements began, and was extended, by irradiation, to those covering, in vision, the *white spot* in the centre; being, there, sufficient to *neutralize* the *red* rays of the white, and thus allowing only green to be seen, by vibrations of the *green-resonating* rods and cones of *that part* of the retina.

On turning then to a *white ground*, most of the retina being *charged with red* by the previously contemplated red ground, the usual *complementary, green*, spectrum of that ground is seen; but at the *central* part of the retina, whose *green-resonating* elements have been set in vibration (as above said), *their* vibrations are annulled by the *green rays* of the white ground; leaving only the red rays of that ground to take effect, and producing a (secondary) red spectral spot upon the green.

These facts are, it appears to me, all closely similar in nature to the commonly observed interference occurring between diffused sunlight and lamp or candle flame; and, also, they have a definite relation to the mode of production of the Fraunhofer dark lines or "absorption bands" of the spectroscope; while they suggest some further speculations in regard to what may be the molecular conditions of reflecting surfaces which give to our vision impressions of different colors, to enter upon which, at present, would extend this communication to too great a length. I may simply add that, on careful examination of ocular spectra obtained by looking at colored objects by lamplight, as well as by sunlight, I have become convinced that the influence of light entering through the *closed lids*, if they are uncovered and within range of a luminous source, such, even, as that of a student's lamp, is not at all indifferent. A spectrum, obtained as usual, seen with closed eyes, and fading away while they are covered, may be *renewed* by approximating the eyes, *still closed*, to the light; and this again and again, several times. In order to test yet farther the sensitiveness of the eye, when closed, to light, I placed several pairs of glass slips, of different colors (blue, red, green and orange), in the hands of an assistant; laying them, then, as given to me, in turn, upon my closed lids, while my eyes were turned towards the afternoon sun. In every case, I could discern clearly the color of the glass; but only in the direct rays of the sun; diffused daylight, and lamplight failed, with me, to give more than a doubtful discrimination of color, even with near contact of bright translucent objects, while the eyes were closed.

Incidentally, I may mention also, my careful repetition of a very curious experiment mentioned by Sir. David Brewster in his Optics, and brought to my notice by Prof. E. J. Houston. A strip of white paper is held vertically, about a foot from the eyes; the attention is then fixed upon an object at a greater distance, so that the slip of paper is seen double; and at the same time a lighted candle is brought near to the side of one eye, so that its light will affect that eye strongly. The image of the strip seen by that eye (if the *right eye* be illuminated, the *left-hand image*, and *vice versa*) will be *green*, and the other *pale red*. I find that, when these two images have been obtained, one eye can be closed, but the same color still remains. Brewster asserts that when *two* equal candle-lights are used, one being held near each eye, two *white* images will be obtained. With me, this does not prove to be the case. I see, with two candles, *two green* images instead; and, fixing the eyes on the strip for *single vision*, with two candles placed as before, it is seen of a *distinct green* color. Without insisting upon it, I would pro-

pose as a hypothetical explanation of these results, the throwing of *red light* upon the retina by the light of the candle passing *through the blood vessels* of the eye-ball; this red light, in the eye most illuminated, *killing* the red-light vibrations of the retinal elements, so that only green is seen. The pale red of the image seen by the *unilluminated* eye is, with me, of doubtful distinctness.

If the facts and arguments which I have set forth in this paper impress other minds as they have done my own, especially in view of the *instantaneousness* of many of the phenomena described, and on which I have wished to lay particular emphasis, it may, at least, be concluded, that the commonly accepted theory, proposing to account for negative and complementary spectra by partial *fatigue* and diminished *sensibility* in the retina, will not suffice; and ought to be abandoned, as not at all reconcilable with several clearly demonstrable facts. Should my above attempted explanation, by *interference* (or *saturation* of the retina with certain luminous rays, and *neutralization* of a portion of the same by equivalent rays present in reflected white light), not prove altogether satisfactory, it may be an interesting task, not without importance in physiological science, for some one well-versed in the physics of the subject to give it such farther attention as may solve the problem, in a manner which meets, as has certainly not hitherto been done, all of its conditions. I ask leave to verify some of my assertions as to the facts referred to in this paper, by repeating here a few of what appear to me the most decisive of the experiments which have been mentioned.

Stated Meeting, April 7, 1876.

Present, 19 members.

Dr. LeConte, in the Chair.

Letters of acknowledgment were received from the Batavian Society at Rotterdam (XV ii, 94); the Royal Observatory at Bruxelles (XV ii, 94); the Royal Astronomical Society (XIV); the Society of Antiquaries (95), and the Victoria Institute in London (95).

Letters of envoy were received from the Zoologico-Botanical Society at Vienna, March, 1876, and the Meteorological Office at London, dated March 20, 1876.

A letter requesting missing Nos. XIV, ii, 62, 88 was received from the R. Astronomical Society, dated February 16, 1876.

A letter was received from Mr. Cleveland Abbe, requesting missing Nos. 93, 94, dated Army Signal Office, Washington, D. C., March 20, 1876.

Donations for the Library were received from the St. Petersburg Botanical Society, Danish Academy, Königsburg Physical Society, the Societies at Ulm and Erlangen, Turin Observatory, Vaudois Society, Bordeaux Geographical Society, Paris Geographical Society, Revue Politique, Nouvelles Météorologiques and Journal des Orientalistes, London Astronomical Society, Meteorological Committee, and Nature, Greenwich Observatory, Boston Academy and Natural History Society, Silliman's Journal, American Chemist, Poughkeepsie Society, Buffalo Scientific Commercial, New Jersey Historical Society, Penn Monthly, Pharmaceutical Association, Medical News, and the Department of the Interior at Washington.

The Committee on Dr. Valentini's memoir reported that they desired further time to compare the photographs with the Mexican calendars in the Poinsett collection of the Society, which was granted.

The death of Theodore Cuyler, on the 5th inst., aged 55, at Philadelphia, was announced by Mr. J. S. Price, and on motion Mr. Henry M. Philips, was appointed to prepare an obituary notice of the deceased.

The death of Hakakian Bey of Cairo, a member of this Society, was reported by the Secretary.

A thesis entitled "Physiological Action of Strychnia, by Dr. Wm. H. Clapp," which had received a prize at the recent commencement of the Medical Department of the University of Pennsylvania, was offered for publication by Dr. Carson through the Secretaries.

A thesis entitled "Sanguinaria Canadensis and its Alkaloids" by Robert Meade Smith, A. B. which had received a prize at the same commencement, was offered for publication by Dr. Francis Gurney Smith through the Secretaries.

These communications were on motion referred to a Com-

mittee composed of Dr. Henry Hartshorne, Dr. Bridges, and Dr. Horn.

Mr. E. K. Price concluded the reading of his Discourse on the Glacial Theory.

Prof. Chase communicated, with blackboard illustrations, some astronomical ratios favoring the Nebular Hypothesis.

Dr. H. Hartshorne postponed the reading of his paper "On some disputed Points in Physiological Optics with experiments" to the next meeting.

Gen. Kane made a preliminary communication of his views of the Sub-carboniferous formation and of the structure of McKean County, Pennsylvania, based upon surveys pursued by him through many years.

Pending nominations Nos. 792 to 802 were read.

A report of the Curators was read recommending that the request of Mr. Etting be granted, and on motion, the Librarian was authorized to deliver to Mr. Etting the Original Draft of the Declaration of Independence, owned by this Society, and to take his receipt therefore, and his agreement to preserve the document in a fire-proof safe, except on hours of public exhibition, and protected from the direct rays of the sun, and to return the same on or before the first of January, 1877, according to the terms of his letter of March 23d, 1876.

A report of the Library Committee was read, recommending that the request of Holman & Co., be granted, and on motion the Librarian was authorized to deliver to Mr. Holman the Elliot Bible in the Library of this Society for exhibition in the Centennial Buildings, taking his receipt therefor, and his agreement to return the same in good order on or before the first of December, 1876.

The Treasurer's Report (postponed on account of illness) was read.

The resignation of Mr. Samuel J. Reeves as a member of the Society was read, and on motion accepted.

And the meeting was adjourned.

Stated Meeting, April 21, 1876.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the Institute National de France, dated March 31, (XIV iii, and asking for Vol. V i, N. S. and XIV ii), from the Radcliffe Observatory, Oxford, March 30, and from the New York State Library, April 15.

Donations for the Library were received from the Prussian Academy, Annales des Mines, Nouvelles Météorologiques, Revue Politique, Nature, Mus. Comp. Zool. Mass., American Chemist, Cap. Jas. C. Cole, Franklin Institute, Am. Jour. Med. Sciences, and Mr. A. H. Worthen, of Springfield, Illinois.

Dr. Ruschenberger was, on motion, substituted for Dr. Hartshorne on the Committee to report on the publication of the medical theses presented at the last meeting, at the request of the latter.

Dr. Hartshorne read a paper on complementary spectra, rejecting the commonly received "Fatigue Theory," and offering a new explanation based upon the interference of light rays, illustrating his views by means of colored papers, and the magnesian light.

Prof. Chase communicated certain relationships which he had worked out between the velocity of light and the rotation of Mr. Crooke's new rotation apparatus, and with the phenomena of the "Silenium Eye." To these he added some fresh calculations of the weights of the planets.

Prof. Frazer read a communication which he had received from Mr. Beyton Smith, C. E. of York, Pa., giving a sketch of the literature of the belief in one magnetic pole

of declination, and of the counter belief in the existence of two such northern poles; followed by a brief statement of the results of his own field observations and calculations, leading him to the conviction of the existence of two poles, and enabling him to locate their two ellipses of rotation, approximately; not as accurately as he desires to have it done by a more skillful mathematician; but with such an approach to exactness as to be practically useful in his own tests of the age of any given land line. Both poles are located nearly on the 70° parallel of north latitude; but while the ellipse of the American pole lies nearly in a North and South direction, that of the European pole lies nearly East and West. Mr. Smith is anxious to have mathematical assistance in projecting his ellipses upon a map or globe.

Prof. Houston desired the Society to make a note of some curious observations he had made recently while using Plucker tubes for obtaining the hydrogen spectrum, and modifying the internal diameter of their capillary tubes with a view to regulate the flow of the gas. In proportion as the resistance was increased, crimson spots and lines appeared, and finally the crimson color filled the entire space.

Pending nominations Nos. 792 to 802 were read, and balloted for, No. 793 being on motion postponed on account of the absence of the nominator.

The report of the Finance Committee was presented by Mr. Fraley, and the appropriations recommended by the Committee for the ensuing year, were on motion passed.

The ballot boxes being scrutinized by the presiding officer the following named gentlemen were declared to be duly elected members of the Society:

Col. Frank M. Etting, of Philadelphia.

Dr. Daniel C. Gilman, President of the Johns Hopkins University at Baltimore.

Mr. P. Cunliffe Owen, of South Kensington, London.

Mr. I. Lowthian Bell, of Newcastle on Tyne, England.

Mr. James Geikie, of Scotland

Prof. Thos. C. Archer, of Edinburgh.

Dr. Adolph Erik Nordenskiold, of Stockholm.

Mr. C. Juhlin Dannfelt, of Stockholm.

Mr. Elihu Thompson, A. M., Prof. Chemistry in the Philadelphia High School.

Mr. Charles V. Riley, President of the Academy of Sciences, St. Louis, Missouri.

And the meeting was adjourned.

Stated Meeting, May 5, 1876.

Present, 10 members.

Secretary, Dr. LeConte, in the Chair.

Visitors: Mr. Deby, of the Belgian Commission, and Mr. König, of Paris.

Letters accepting membership were received from Mr. Frank M. Etting, of Philadelphia, and Dr. D. C. Gilman, of Baltimore.

A letter declining the appointment to prepare an obituary notice of Mr. Cuyler, was received from Mr. H. M. Phillips, dated 1325 Walnut Street, Philadelphia.

On motion, Mr. Phillips was excused.

Letters of acknowledgment were received from the Regents of the New York University, and Boston Natural History Society (V ; 94).

Letters of envoy were received from the Secretary of the Geol. Survey of Pennsylvania, May 4 ; London Meteorological Office, R. S. April 8, and Royal Astronomical Society.

Donations for the Library were received from the Academies at Buda-Pest, Vienna and Bruxelles ; the Societies at Bonn, Göttingen, Ulm, Zurich, Geneva, and Cherbourg ;

the National Museum, and Geographical Society at Paris; MM. Rütimeyer and Alb. Müller at Basil; the Meteorological Office and London Nature; the Boston S. N. H.; Mr. E. D. Cope; Prof. O. C. Marsh and Silliman's Journal; the Franklin Institute; Academy of Natural Sciences; College of Pharmacy; Penn Monthly; the Manager of the House of Refuge; Dr. D. C. Gilman, of Baltimore, and Mr. S. S. Sherman, of Milwaukee.

The Committee to consider the propriety of publishing the medical theses presented at a previous meeting asked and obtained leave to postpone their report for another fortnight.

Prof. Frazer read a *resumé* of the important points in the memoir and maps of M. Delesse, entitled Lithologie des Fonds de Mer.

Prof. Frazer, also, made some preliminary remarks upon the possible effects upon species and genera of living beings to be supposed to arise from variations in the proportionate percentages of the chemical elements of their physical constitution, under the operation of the law of the "survival of the fittest," leading to the conclusion that, were the chemistry of organic bodies suitably modified, it might be possible for them to exercise the functions of life in otherwise destructive circumstances, as, for example, in solar heat. He postponed the reading of a paper which he had prepared on the subject to a future meeting.

The reading of the pending nominations, &c. was postponed, and the meeting was adjourned.

Stated Meeting, May 19, 1876.

Present, 11 members.

Prof. P. E. Chase, in the Chair.

Mr. Selwyn and Mr. Carll, new members, were introduced to the presiding officer, and took their seats.

Visitors from corresponding societies, Mr. Honeyman and Mr. Lawson, of Nova Scotia.

A letter accepting membership (with photograph for the album) was received from Prof. Thos. C. Archer, dated Philadelphia, May 7, 1876.

Letters acknowledging the reception of publications were received from the Société Hollandaise, dated Harlem, February 1876 (XV ii, 94); the Foundation Teyler, dated Harlem (92, 93); the Statistical Society, London April 26, (95); the N. H. S of Northumberland, D. and N. upon Tyne, April 25, (95); the Royal Society of Edinburgh, February 21, (92, 93).

Letters of envoy were received from the S. Hollandaise March; Cent. Obs. St. Petersburg, March; Fondation Teyler, Harlem; and Department Interior, U. S., Washington, May 6, 1876.

Donations were received from the Royal Academy at Berlin; the Musée Teyler; Society of Anthropology and Revue Politique at Paris: M. LeComte Leopold Hugo, at Rome; the R. Geographical, R. Asiatic, and Chemical Societies and Victoria Institute at London; Nature; Radcliffe Observatory; M. Juhlen Deby: R. Society at Edinburgh; R. Dublin Society; Canadian Naturalist; Boston S. N. H.; State Board of Health, Mass.; American Chemist; Franklin Institute; Mr. John E. Wootten; Medical News; Second Geol. Survey of Pennsylvania; Department of the Interior and Engineer Department U. S., Washington; Dr. J. H. Kidder; Young Men's Association, Buffalo; and the Scientific Monthly at Toledo, Ohio.

The Committee to whom was referred the medical prize theses, reported.

Mr. Honeyman, by invitation, read a paper on the varieties of transported boulders found by him in the banks and "red heads" of the Nova Scotia shore for twenty miles east of Halifax, and along the harbor and railways to Winsor and Pictou; showing, by means of a colored map, and specimens containing fossils, and specimens of amygdaloid, agate, syenite, dolerite, diorite, granite, iron ore, &c., that the deposit at Halifax was the terminal and medial moraine of a glacier having its base along or behind the Cobequid mountains, 80 or 90 miles distant, and that the arc of collection and dispersion, of which Halifax was the centre of concentration, had an amplitude of 45°. The striæ on the rocks towards Halifax had an average trend of S. 5° E.; towards Windsor of S. 20°—30° E.; and towards Pictou of S. 25° W.

The thanks of the members present were warmly expressed by the presiding officer and others.

Professor Houston described some results which he had got with a Crooke radiometer in a good Geissler tube of his own manufacture, going to show that light was ancillary to heat in the action of the instrument. Presenting, however, non luminous rays of heat, as for example from heated copper, a small but decided motion was obtained. Moonlight gave no motion, but he intended to concentrate moonlight on the flags by means of a 16″ Fresnel lens.

Mr. Briggs reminded him that the thermopile revealed heat rays in the moonbeams, and an alum plate would be required to make the experiment satisfactory.

The minutes of the last meeting of the Board of Officers were read.

Pending nominations Nos. 793 and 803 were read.

On motion of Mr. Price, the Secretaries were instructed to reply to Mr. Kesselmeyer's letter, respecting the Calendarium, declining his proposals.

And the meeting was adjourned.

NOTE ON THE "LITHOLOGIE DU FOND DES MERS" OF M. DELESSE.

By Prof. Persifor Frazer, Jr.

(*Read before the American Philosophical Society, April 21st,* 1876.)

M. Delesse acknowledges his indebtedness to the treatises in Geology of Elie de Beaumont and Jas. D. Dana, in the first few prefatory pages. The following shows the scope and direction of the work:

I. Preliminaries. Methods pursued in studying the deposits. Orography of France and her submarine shores.

II. Principal agents of marine deposits.

Organic agents.

Inorganic agents { External { Atmosphere. / Fresh and brackish waters. / The Sea. } / Internal { Subterranean waters. / Eruptions. / Dislocations. }

III. Marine deposits of the Coast of France. Shore deposits and submarine deposits. Distribution of Mollusks.

IV. Lithology of the principal seas of the globe. France. The ancient world. The modern world.

V. France at different geological epochs. Deposits of the ancient seas of France. Changes undergone by these deposits.

M. Delesse then describes his methods of investigation.

Fine sand is treated with hydrochloric acid, its loss of CO_2 determined, and this multiplied by 2.27 to obtain the carbonate of lime. This method is accurate enough. Magnetic iron is separated by a magnet. Part of the gangue comes out with the magnet. This augments the magnetic sand on the one hand; on the other much of the magnetic sand is not taken up; so that these two errors are on opposite sides.

Sands and gravels examined contained 0.54 to 2.70 p. c. of soluble material (sea salts and organic matter). Argillaceous sand has a tendency to remove salts from the water containing them.

The classification of the deposit was had without recourse to chemical analysis, by the microscope.

The sieve used had meshes with a diagonal of 1 mm. The universality of the presence of quartz is very striking. Even vegetable mould and that too resting on calcareous rocks show a notable proportion of quartz. Quartz is more abundant the more the waters are agitated.

The sand dunes of the coasts of France are mainly composed of hyaline quartz, whitish gray. They slope gently towards the sea at about 7°; landwards about 29° to 35°, and have been seen to advance in a high wind in spite of a heavy fall of rain 0.6 m in three hours. The absence of mud in dunes is noteworthy but easily explained, since this substance hinders the formation of dunes.

The minimum rainfall in France is in the region bordered by Troyes, Meaux, Compiègne, Epernay (40 centimetres).

On the Ain (one of the affluents of the Upper Rhone) it is over 120 centimetres.

Up the Seine from Paris about 28 p. c. of all the water which falls in whatever form finds its way into that river (within that hydrographic basin); 53 p. c. in the basin of the Saône near Trevoux. For the Garonne above Marmande and for the Auxois which flows over impermeable marls it rises to 65 p. c. The percentage increases in schistose and granitic regions.

It is noticeable that the rivers which flow over calcareous beds do not exhibit a large amount of limestone in their *débris*, as for example the Loire. This is attributed to the softness of calcareous fragments and their inability to resist triturition. [It may be remarked that this explanation will only apply to the deposits at considerable distances from the edge of the calcareous formation, for otherwise the waste would be constantly renewed.]

400 metres from the mouth of the Lez the sandy deposits contain over 60 p. c. of carbonate of lime. At the mouth it consists of 23 p. c. carbonate of lime, with great numbers of flakes of green mica.

The Herault 600 m. from its mouth deposits a reddish gray gravelly sand, consisting of hyaline quartz with orthoclase, feldspars and granitic *débris*, much argillaceous schist, reddish brown mud, gray mica schist, greenish quartz, sand, and some tablets of silvery mica.

Magnetic sand is found here in large quantity and is derived from the igneous rocks over which the river flows.

These few notes will serve to convey an idea of how this part of the subject is treated.

By far the most striking, as the most valuable, part of M. Delesse's work is to be found in the elaborate charts which accompany it. The character of these charts as specimens of map printing is very high, although it is questionable if the condensation of a great number of unallied statistical facts upon one sheet is favorable to the easy comprehension of such charts. A better plan would be to reproduce the same outline several times with different and strongly marked coloration or shading than to construct all curves of every kind upon one frame work, thus causing them to cross and recross one another to the bewilderment of the eye. Another difficulty for the reader arises out of the method adopted by M. Delesse for conscientiously representing all his facts upon a single sheet. Had the several kinds of curves been strongly portrayed they would so attract and confuse the eye as to entirely destroy the effect of the map as a whole. To avoid this the lines have been made so exceedingly fine, that if any one try to follow one of these curves he will need either an exceptionally good eye or a magnifying glass; in either case the character of a *boundary* between a territory on one side and a territory on another fails: for the moment the observer seeks to take in the entire curve at a glance it becomes invisible.

The datum plane is sea level. Heights are registered in the metre curves and depths by similar means. But in approaching the mountainous regions of France, one half the contour lines are omitted, lest they should shade

these portions of the map too deeply to allow of the delineation of the other portions. The unnatural effect is produced, of a map constructed on two different hypsometrical scales.

The distribution of rock, sand, slime, etc. along those sea bottoms which have been best observed (as for instance in the British Channel and along the routes of various deep sea sounding lines) is very interesting.

The great distance to which fluviatile sediments are carried and the separate although adjoining areas which the suspended matters of two widely separated river systems will occupy is strikingly shown in the distinct belts of St. Lawrence and Mississippi sand which overlap for 500 miles along our coast without commingling.

For his contribution to our knowledge of our own coasts M. Delesse deserves the hearty thanks of every student of American physical geography and geology.

Mr. Lesley added his testimony to the great value of the work of M. Delesse, of which Prof. Frazer had spoken:

He hoped that the Lithologie du Fond des Mers would be translated into English, and the magnificent maps accompanying it republished for the use of American geologists. If only the one map of the American continent and its enclosing water-beds were published, showing by colors the different sediments which issue from our rivers, and are distributed by tidal currents along our coasts, it would be a most valuable addition to our handbooks of geology. Many of the problems of erosion and sedimentation in Mesozoic and Kainozoic times, are plainly helped to solution by this map.

One of the most striking features is the contrast between the sediment in front of the coast from Maine to Alabama, and that of the sediment filling the St. Lawrence Gulf, and tapering southwards to a point opposite Norfolk. The former sediment fills the in-shore angle of the Gulf of Mexico, in front of Pensacola; the latter is repeated as an outside belt, stretching from the mouth of the Mississippi to a point in front of Havana.

It is easy to see the cause of the difference. The inside sediment descends the rivers which drain the siliceous and feldspathic mountains of New England, New York and Pennsylvania, Virginia, the Carolinas and Georgia, composed of Azoic and Palæozoic formations. The outside sediment descends the St. Lawrence and the Mississippi, and represents the drainage of the argillaceous and calcareous interior of the continent, composed of the Sub-carboniferous limestone formations east of the Mississippi, and of the broad stretches of Cretaceous and Tertiary rocks between the Mississippi and the Rocky Mountains.

The map suggests plainly the cause of the difference between the constitutional features of the eastern and western Cretaceous and the eastern and western Tertiaries.

A thousand details of this nature will repay the student of the map, to construct which must have tasked the zeal, as well as the knowledge, of the distinguished French geologist, its author, to the utmost.

M. Delesse is naturally desirous that this map should be known to American geologists, and to receive from them, directly or indirectly, such criticisms of it as will enable him to improve it in future editions.

THE GLACIAL EPOCHS,

By Eli K. Price.

(*Read before the American Philosophical Society, March* 3, 17, *and April* 3, 1876.)

The Geologists speak of the Glacial Epoch, with a ready confidence that implies they consider it an admitted doctrine of their science; and they mean by "the glacial age," one of continental ice sheets. Glacialists have written large volumes on the subject, and its literature is swelling into a library. Agassiz, born and educated among the Alps, studied their glaciers and their effects, and traveling thence, applied his theories to other parts of the world. He was very sincere in his convictions, and complained that so few of his colleagues accepted his views; but in the confidence that he held a great truth he was willing to abide the coming of the time he foresaw, when Geologists would generally accept his theory. That time seemed to have arrived before he died, with some distinguished exceptions.

Those who have made Geological Surveys of England and Scotland, and parts of the Continent of Europe, either as conductors of public Surveys, or as Professors in colleges, or teachers through the press, find the ready explanation of what they see, in the doings of the great Glacial Epoch, when the supposed Northern ice-sheet filled the Arctic Ocean, the British and Irish Seas, and covered Northern Europe continuously over land, rivers, seas and mountains, to shed its icebergs far out into the Atlantic. And so too in this broad country, the Geologists who have made our public Surveys, who teach in our colleges, or publish, have generally read the rocks and drifts in the same way, in making explorations that have extended over the length and breadth of this continent.

Geologists, as other scientists, must follow the truth as the facts of nature compel them. Truth's compulsion is as inexorable as the pressure of the gigantic ice-sheets, these glacialists suppose, bore down from the pole. But they, as others, must often review their facts before they accept a theory as conclusive, and make themselves sure that they have not, by an engrossing attention to limited facts, overlooked others which should have influenced their theorizations.

They teach that the Glacial Epoch has occurred twice at least, since the rocks were laid in the strata as we see them; long after the coal measures were formed; of which the evidence is to be found upon the surface of the rocks as they now exist, and in the clays, and drifts, and boulders now spread over those rocks. Geologically speaking, these phenomena are of recent date, although before the Niagara began to cut the channel we now see. The astronomical cause assigned for them gives them a periodicity of about twenty-one, to twenty-two thousand years, and our northern hemisphere the respite of the half of such period, before it shall again be ground into paste.

We have the deepest interest, as a truth of science, to know what have been the causes that have deeply modified the surface of the world we inhabit; and a yet deeper interest in knowing what shall befall that part of the northern hemisphere now occupied by the most intelligent and civilized portion of mankind, with their wealth, cities, cultivation, and works of transportation and travel; for if the theory be true all these will be ground into the comminution of the boulder clay that flows from beneath the glacier of the Alps! When men pay for real estate they exact an extreme scientific care that they get a fee simple title forever, Why be so anxious, if all is to be razed, leaving them an interval of but a term of years. Yet more; we cannot but sympathize with a posterity destined so to perish; and with the shock to the faith of those who believe in a Creator, capable, and willing to conserve His creation.

Let us then see what this supposed continental ice-sheet is. Listen then to the very words of Agassiz, author of the theory: "It is a sheet of snow ten or fifteen thousand feet in thickness, extending all over the northern and southern portions of the globe; and must necessarily lead, in the end, in the formation of a northern and southern cap of ice, moving to the equator." Speaking of the northern, Agassiz further says: "As to the southward movement of an immense field of ice, extending over the whole north, it seems inevitable, the moment we admit that snow may accumulate round the pole in such quantities as to initiate a pressure radiating in every direction," "alternately thawing and freezing, it must, like water, *find its level* at last." "In the State of Maine, I have followed, compass in hand, the same set of furrows, running from north to south in one unvarying line over a surface of one hundred and thirty miles from the Katahdin Iron Range to the shore. These furrows follow all the inequalities of the country, ascending ranges of hills varying from twelve to fifteen hundred feet in height, and descending into the intervening valleys two or three hundred feet above the sea, or sometimes even on a level with it." (A Journal to Brazil, 403, 402.) These all are words of Agassiz, with no word of apprehension or sympathy for his fellow beings, for whose welfare the noble labors of his life were devoted.

Agassiz gives further explanation of his views on the "Ice period in America," in the *Atlantic Monthly* for July, 1864. The ice moved over the continent as one continuous sheet overriding nearly all the inequalities of the surface, p. 88. Fragments of rocks from Lake Superior are found in New England, and northern rocks on the prairies of Illinois and Iowa, down to the fortieth degree of latitude. Polished rocks and straight scratches may be seen for hundreds and hundreds of miles. The slopes of the Allegheny range are glacier-worn to the very top, with the exception of a few points. Mount Washington is over six thousand feet high and wears glacier marks to near its summit. Here the thickness of the sheet could not have been less than six thousand feet. If much lower than that the ice passed over the mountains. He asks us to imagine the climate of Greenland brought down to the fortieth degree of latitude, with ice thousands of feet thicker

than it is there at present. Norway, Sweden, Scotland, England, Ireland, were so covered, p. 92. This, it is true, was long ago; yet late cave explorations are supposed to indicate, that the latest glacial epoch was since man inhabited the earth.

Professor Winchell, adopting the glacial theory, states its causes and effects. He rather delights to make science sensational and astonishing. "The high northern latitudes experience an *unwonted uplift*. Arctic lands raise high their dripping heads above the temperate waters of the polar zone. The climate of the whole northern hemisphere feels the change. No moving currents can now bear torrid warmth to the frozen sea, and return the colder waters to the equatorial zone." "The snows of many winters are gathered on the slopes of Northern America." "Glaciers brood over all the land." "The marks of this stupenduous glacier are yet visible." "The northern limit was chained by eternal frost to its rocky bed. The southern only was free to move, and the whole expansion would be developed along the southern border." (Sketches of Creation, 214.) "From season to season, and from year to year, the mighty mass marched irresistibly forward, mowing down the forests, crushing tree-trunks, or burying them with the rubbish of the rocks, from ten to sixty feet below the surface." "The great glacier moves onward." "It bridged Niagara River; it bridged Long Island Sound, and bathed itself in mild waters of the ocean beyond," p. 218. 219. "It made a *tabula rasa*." River channels were filled up; "In Ohio and Indiana these buried river-beds are of frequent occurrence. The ancient gorge of the Niagara River was filled by the obliterating agency of this continental glacier." "It wiped out the trifling furrow, * * making it necessary for the river to begin anew its work," 219, 220. It bore rocks southward twenty, fifty, and even five hundred miles. "These fragments have been transported over lakes, sounds and seas." The glacial agency is not recognized south of the Ohio River, 220, 221. The south was spared; nay, greatly favored; for except the chain of mountains, the material ploughed up by the ice was carried by the waters to make the Cretaceous seaboard, the Gulf states and the many more of the Mississippi, and Missouri valleys.

This reign of ice came after the close of the carboniferous age, and after the land was upraised and dry, and vegetable and animal life existed on it as now, except that man was not yet here. Winchell is so speaking (219, 213), and then says, "Next in the order of vicissitudes was a grand continental subsidence. Vast areas of Northern America, that had been raised to the altitude of perpetual snow, were gradually lowered to the ocean's level. Again the interchange of equatorial and polar temperatures was affected by the moving sea-currents, and the climate of summer smiled over the desolate empire of frost," 222. "By degrees Wisconsin, Michigan, New York, Ohio and other Northern States disappeared beneath the waves," p. 228. "It seemed like a failure of the plan of creation. The land gained by *unnumbered throes* of the continent was lost. The higher summits only held their heads above the level of the careering

waves. Deposits bearing the marks of oceanic action reach to an elevation of six thousand feet on *Mount Washington, two thousand* or more on the Green Mountains, and *three thousand* on Monadnock. But this deep submergence was not of long continuance. Slowly the continent rose again from its deep sea burial," 229. Thus the continent here, as we shall see in Europe, seems to rise and fall thousands of feet at the bidding of theorists.

The Ohio Geological Report of 1873, written by Dr. Newbury, is equally threatening; 1 vol. 85: "The period immediately following the Tertiary age in geological history, but separated from it by we know not how many thousands of years, presents us with a complete change in the physical condition not only of our own continent, but apparently of the whole northern hemisphere; a change not exceeded by that which takes place upon our surface in the alternations of season from mid-summer to mid-winter. We have abundant evidence that during what is called the drift period the climate of our continent had changed from the all pervading warmth of the Tertiary to an all pervading arctic cold. While in the former age the climate of our Southern States was carried to Greenland, in the latter the *present climate of Greenland was brought as far south as the Ohio.* The continent of Greenland is now nearly buried under snow and and ice." "Precisely such must have been the condition of much of the North American Continent during the glacial period, for we find evidence that glaciers covered the greater part of the surface down to the latitude of 38 or 40 degrees." The smoothed and grooved rocks are covered with the glacial drift deposits; and upon and mingled with it, is the Erie clay; deposited from suspension in water and stratified; doubtless from basins where had been the retreating glaciers, p. 86.

If geologists did not produce so many restorations of the past, full of wonderful instruction, we would be apt to say that surely the imagination had large operation in making such confident explanations of the past doings of Nature upon this globe. Grand, sublime, were and are her operations; but one cannot help thinking if they could be seen that their progression was slow and orderly, without extreme vicissitudes, and as harmless as we now see them. There was ample time for the work; and Geologists readily allow any amount needful for observed effects, counting a thousand years as a day. The sedimentary rocks show that the process was generally a quiet one, the more modern with fewest faults; and certainly nothing could have been more carefully done, than the manner of the growth and storing away of the coal and oil, under their rocky coverings for the use of the human beings that were to occupy the world. Excepting the ventilating volcanoes, and the mountain-heaving earthquakes, the elevations and depressions of the earth have been at the rate of but a few feet in a century, so that it can hardly be soberly said that the land was gained by "unnumbered throes." Nay the probability seems to be that the concurring operation of the sinking of the sea beds and the raising up of the mountains, the one balancing the other, were then as now, only to be gauged by the lapse of the centuries, so quiet and imperceptible were they. Geology

has no chronology of years, but only of the order of its own successions, and the preparations, in the "beginning" of this earth, for man, there is every evidence was very long, and not violent.

James Geikie writes in more measured and careful language than any of those who have lately written on the Glacial theory; and he may, therefore, be allowed to be its reliable expositor. Writing "The Great Ice Age," he says, "We must believe that all the hills and valleys were once swathed in snow and ice; that the whole of Scotland was at some distant date buried underneath one immense *mer de glace*, through which peered only the higher mountain-tops. This is no vague hypothesis, or speculation founded on uncertain data, no mere conjecture which the light of future discoveries may explode. The evidence is so clear and so overwhelmingly convincing that we cannot resist the inevitable conclusion." p. 82. "Now the scratches may be traced from the islands and the coast-line up to the elevation of at least 3,500 feet; so that ice must have covered the country to that height at least." 83. Agassiz added one-third to the height scored, that the ice-sheet might have a back pressure to pass it over the elevations. "Such changes happened not once only, *but again and again*," says Geikie, 200.

Of North America, Geikie says, It is no exaggeration to say, that the whole surface, "from the shores of the Arctic Ocean to the latitude of New York (City), and from the Pacific to the Atlantic, has been scarped, scraped, furrowed and scoured by the action of ice." 411.

And the conclusion of Geikie's Great Ice Age is this. "Upward of 200,000 years ago the Earth, as we *know from the calculations of astronomers*, was so placed in regard to the Sun that a series of physical changes was induced, which eventually resulted in conferring upon our atmosphere a most intensely severe climate. *All Northern Europe* and *North America* disappeared beneath a thick crust of ice and snow, and the glaciers of such regions as Switzerland assumed gigantic proportions. The great sheet of land-ice leveled up the valleys of Britain and stretched across our mountains and hills down to low latitudes in England." And so it is said as to the north of Europe. "Ere long this wonderful scene passed away. Gradually the snow and ice melted; the arctic mammalia disappeared; the climate grew milder, until something like perpetual summer reigned in Britain. Then it was that the hippopotamus wallowed in our rivers, and the elephant crashed our forests; then, too, the lion, the tiger, and hyena became denizens of the English caves." Then after a "long time" it grew cold; these tropical animals disappeared, and the arctic beasts came back; but the climate became so severe that even these "migrated southward, *until all life* deserted Britain, and snow and ice were left in undisputed possession. *Once more* the confluent glaciers overflowed the land, and desolation and sterility were everywhere." "We cannot say how often such alternations of cold and mild periods were repeated." "A similar succession of changes transpired in North America." The palæolithic man was here in the inter-glacial period, and frozen out! 534, &c.

In Scotland "the direction of the scratches, ruts, and grooves upon the rock head, usually *coincides with the trend of the valley* in which the till occurs." Geikie's Ice Age, 21. "In the Northern Highland * * they keep parallel to the trend of the great glens; and in the Southern Uplands, likewise, they follow all the windings of the chief dales and 'hopes.'" p. 80. A hope is a sloping plane between ridges of mountains. Let us remember these local indications.

And James Geikie asks, "What do we learn from the erratics?" the far-traveled blocks over the whole face of the country. "The highland boulders on the Pentlands and Lammermuirs, for example, after crossing Strathallan or Strathearn, traversed either the Campsie or Ochil Hills, and passed athwart the broad vale of the Forth before they finished their journey. By what agent were they transported? The answer is by a colossal glacier." p. 223–4. "It is a fact that most, if not all, the *erratics* have traveled in directions that coincide with the *trend of the rock-striæ*." "The erratics lying loose upon the ground have moved in the identical direction, followed by the till of the same regions; a direction which it need hardly be said coincides with that of the underlying rock-striations. Indeed, when the *till* is carefully searched it not infrequently *yields fragments of the same rocks* as those of which the erratics lying *loose at the surface* are composed." 224–5. Mark how coincident with the topography.

He further proceeds to say, that after the great glacial deposits of Scotland, "the country at length became submerged to a depth in the south-east and west midland district of probably as much as 1,100 or 1,280 feet." 353, 255. "The river deposits of the lowlands were *now partially re-assorted*, or top-dressed, as it were, by the action of the sea. As the submergence approached its climax the temperature became colder; *ice-rafts floated about*, and *dropped boulders over the sea-bottom*. These are now found floating on the slopes of the reassorted gravels, and enclosed in stratified clays, the character of the shells in which prove the climate to have been severe." 353.

Mr. J. Geikie finds in England, Wales and Ireland the like evidence of glaciation, of depression of the land and inflow of the sea, and the elevation again of the land; but no true *till* has been found in east Anglia. 371. "The striæ upon the rocks, and the direction in which the till has traveled, mark out clearly the path taken by the great sheet of ice which wrapped up Ireland even as it enveloped Scotland." 373.

Scandinavia, Northern Europe generally, Switzerland, the Vosges, Black Forest, and Pyrenees, bear evidence of former Arctic conditions. "Even as far south as latitude 37°, the former existence of glaciers in the Sierra Nevada has been proved;" * * "and so on with most, or perhaps all, the hillier regions of Europe, great snow fields existed where now there are none," or but "insignificant successors." 379. And the like account is given on the testimony of travelers of Caucasus, Atlas, Lebanon, the Himalaya, and mountains in the north of China and in North America. "The direction of the glaciation in the extreme north of Scandinavia, the

peninsula of Kola, and Northeastern Finland demonstrates that the great *Mer de glace radiated outwards from the high grounds* of Norway and Sweden, flowing *north and northeast* into the Arctic Ocean and east into the White Sea, and thus clearly proving that Northern Europe was *not overflowed by a vast ice-cap creeping* outward from the North Pole, as some geologists have supposed." 382. These are Geikie's words; and here he is at issue with James Croll and Agassiz.

Geikie proceeds: "After that boulder-clay had been laid down, dry land appeared in Scotland and the north of England; and at a later date, a movement of subsidence ensued which resulted in drowning Wales to a depth probably of not less than two thousand feet." "All we know is that Scotland, Wales, and the north of England were largely submerged." Geikie, 479. The south and southeast of England was not submerged, and that portion only contained paleolithic instruments; but the neolithic occur everywhere in and throughout the British Islands; 480; and here were no traces of glaciation; 479; the line of division being the middle of England; 484. The islands and continent became connected; 485.

He says: "It is remarkable, that nowhere in the great plains of Siberia do any traces of glacial action appear to have been observed." Ib. 495. "Consequently we find the great river deposits with their mammalian remains, which tell of a milder climate than now obtains in those high latitudes, still lying undisturbed at the surface." 496.

In the regions of Alaska, west of the Rocky Mountains we have, says James Geikie, "a continuation of the same physical conditions that characterize the more northern latitudes of Asia, namely, great plains intersected by large rivers. Along the banks of these rivers, north of Mount St. Elias, numerous mammalian remains, especially the mammoth, have been detected." "But in the northern latitudes, east of the Rocky Mountains, no such mammalian remains have been detected." "They are rare also or altogether wanting in Canada." "Nevertheless, proofs are not wanting of a former mild condition of things having prevailed within comparatively recent times in the far north of British America." 497.

The glacialists generally find no cause for the great ice sheet, whose effects they see, in the elevation of the mountains, or in ice floods, nor in ice rafts floating from the pole. Mr. James Croll finds its cause in the earth's movement in an elliptical and eccentric orbit round the sun, which is central to one end of the ellipse, so that when the earth moves in the other end of the ellipse it is three millions of miles farther from the sun, and in the extreme of the orbital eccentricity he says fourteen millions of miles further from the Sun; and by reason thereof the warmth of the Sun is lessened at its surface. At this time the Earth is nearest the Sun at our mid-winter, and our winter solstice is supposed to be warmer for it; but by the precession of the equinox, the Sun crosses the equator twenty minutes and twenty seconds sooner than the year before; Geikie 129; by which process our seasons become gradually shifted in relation to the position of the Earth in its orbit, so that in ten thousand five hundred years our winter

solstice will coincide with the Earth's greatest distance from the Sun; 13); hence, greater refrigeration; and hence, according to Jas. Croll, a great ice cap at the North Pole; to be yet more aggravated when such coincidence shall occur at the greatest eccentricity of the Earth's orbit. It is not asserted that in any one year the Earth will receive any less heat from the Sun, or in either hemisphere than in the normal state of the Earth's movements. If the aphelion winter be colder, the perihelion summer would be warmer in the same hemisphere. At the present time these both occur in the southern hemisphere, and we hear of no abnormal cold, or increase of ice. Certainly South America is not invaded by ice, and our ships are going round Cape Horn as usual. It is not known that the glaciers on the Andes have grown higher or longer; while it is known that by the rise of Norway of but three feet in a century, the mountain glaciers have grown longer by about three hundred yards. The good people there need not be in a hurry to emigrate, for in due time the vertical oscillation will be in an opposite direction.

Agassiz says, in his Journey in Brazil, in proof of his opinion, "On my arrival in Rio de Janeiro, * * * my attention was immediately attracted by a very peculiar formation consisting of an ochraceous, highly ferruginous, sandy clay. During a stay of three months at Rio, whence I made my excursions into the neighboring country, I had opportunities of studying this deposit, both in the province of Rio de Janeiro and in the adjoining province of Minas Geraes. I found that it rested everywhere upon the undulating surfaces of the solid rocks in place, was almost entirely destitute of stratification, and contained a variety of pebbles and boulders." p. 299. "There can be no doubt in the mind of any one familiar with similar facts observed in other parts of the world, that this is one of the many forms of drift connected with glacial action. I was, however, far from anticipating, when I first met it in the neighborhood of Rio, that I should afterwards find it spreading over the surface of the country from north to south and from east to west, with a continuity which gives legible connection to the whole geological history of the continent." p. 400. "A sheet of drift, consisting of the same homogenous, unstratified paste, and containing loose materials of all sorts and sizes, covers the country." p. 403. Up the coast at Pará, he says, "I was surprised to find at every step of my progress the same geological phenomena which had met me at Rio," and he was reliably informed "that this formation continued through the whole valley of the Amazons, and was also to be found on all the affluents." p. 405. Now Rio is at the 24th degree of south latitude, Pará at one degree, and the Amazon discharges under the equator. Did then the polar ice cause the phenomenon? If so, was it by a mighty continuous land-borne glacier from the South Pole, or by ices from the Andes, glacial or floating? He gives no explanation here, but elsewhere regards the Andes as sources of the glaciation. He saw the unstratified paste "spreading over the surface of the country." Other geologists, in other parts of the world, find its supposed equivalent, the "boulder clay or till," at the bottom of the drift

formation, and long antecedent in deposition. But there is no reason why the paste should not be formed through all time, where there are mountain glaciers, grinding the rocks of the descending defiles, with a water underflow, frosts and rains, to spread it over the lower country, to an indefinite extent through indefinite time.

There certainly seems to be no warrant for the supposition of a polar ice-sheet over South America, while a cause for the phenomena seen seems much nearer. There are the Cordilleras, ever ice-covered, with valleys filled with glaciers grinding upon the rocks, and making paste or Till of their comminuted materials, and incessant freezings and thawings and rains to carry down the product over the *surface of the land*, now as well as when the first drift deposit was made. Further information is certainly wanted upon this subject, and it may be hoped that Professor Orton, now about to visit the Amazon, may afford it. Mr. Kerr, in his Report on the Survey of North Carolina, in 1875, makes observations pertinent and interesting: "Till or initial drift," which "may be seen everywhere on the hills and slopes of the Piedmont region, and less conspicuously, even in the eastern territory of the Quarternary proper." p. 157. "Evidently these materials" (the gold gravels) "have descended the slopes of the mountains and ridges, at whose bases, or on whose lower and gentle inclines they are found. By what force? Certainly not of water. Neither are they moraines; accumulations at the foot of descending ice masses. They are simply beds of *till*, which have crept down the declivities of the hills and mountains, exactly as glaciers descend the Alpine valley, by successive *freezing and thawing of the whole water-saturated mass, both the expansion of freezing and gravitation contributing to the downward movement;* and with each thawing and advance, the embedded stones and gold particles dropping a little neare the bottom." p. 156. This idea may explain much of the appearances that perplex geologists, without driving them to the theory of an immense polar ice-sheet glaciation. All past time, since the mountains rose from the sea, gives room for normal causes to complete their work, with the results we witness; and account for Till being found upon the surface as well as beneath the drift, and that without a polar ice-sheet.

Those who concur in the conclusion that there have been continental ice-sheets of great thickness, and destructive of all life where they moved, are not agreed as to their cause, source, or extent. Agassiz insists that their cause is cosmic, and more than the normal glaciers of high mountains; and he and James Croll, and Winchell, and others, give them a polar center and a flow towards the tropics down to at least the 39th degree of latitude, and Agassiz extends them into the tropics. James Geikie, with Croll, ascribes to them an astronomical cause, but makes the mountains of Norway and Sweden the source and center of the ice-distribution. Winchell infers a mountain at the North Pole adequate to the production and movement hither of the great ice-sheet. This want of accord among these eminent glacialists is an argument of considerable force to show that the theory is without a tenable foundation.

Beside, the theory is so extraordinary, in its conjectured cause, and so stupendously disastrous in its consequences; and so wholly at variance with the ordinary procedures of Nature, that mankind have a right to take their stand on the stability of normal laws, and to demand the clearest and most indubitable proofs, before they yield their faith in all they have been taught by experience and history.

Uniformity between cause and effect; stability of law; are the basis and surety of all philosophizing. Building on such foundation mankind have believed that this earth is their stable habitation, since man was placed here, and that it is neither to be drowned nor ice-clad, to the destruction of the life upon it. We reasonably infer from all the past that the world was made to support the life it sustains; that the Power that could create both it and that life, and adapted one to the other, had a purpose of their permanence, and would not permit that purpose to become frustrate. Against such an inference, based in all knowledge of what has been, they who assert an impending liability to the destruction of half or more of the human race, with its wealth and civilization, have a right to demand an attesting example in the world's geological history, or reasons more cogent than seem to have been offered, to prove that such destruction awaits the world.

They have a right to say that so general a disaster is not compatible with the established order of the universe. Those who offer an hypothesis, the converse of this ground of security, have the burden of the proof and of the argument resting heavily upon them. The facts they rely upon must be clearly incapable of any other solution; the cause assigned must fit the effect.

All physicists profess to adhere to the normal laws of nature; as the law of gravitation, the movements of the planets, &c., the formations of the rocks, their elevations and depressions; of evaporations, and rainfalls, and congelations, &c.; and he who rests himself on such foundation is to be taken to be upon the true foundation, until it is clearly shown that some eccentricity of nature has been acting exceptionally, and has left the evidences of her exceptional action in manner to be incapable of explanation by her usual laws. Adhering to these laws geologists have generally agreed that in the beginning this Earth was very hot and that its interior was the source of igneous rocks; that it was surrounded by water and steam; and in the pervasive waters the sedimentary rocks were deposited from the eroded materials of igneous rocks, and by incessant repetitions of the erosions of both kinds of rocks, and that as late as the Carboniferous Ages the Arctic had yet a Tropical climate. By heat the Earth was kept expanded, but cooling by radiation it gradually grew less, and the crust of rock became too large for the internal mass, and consequently by its own weight the collapse sunk the valleys and raised the hills, formed the ocean beds and heaved the mountain ranges, and the Earth's rocky covering became plicated and corrugated, yet by a process as gradual and quiet as the radiation of the internal heat. This process was onward until its cause ceased; but the cessation of the radiation was no cause for a glaciation

greater than we witness. By the impulse that produced the rotation of the Earth on its axis, the shape of the globe was reduced from a sphere to an oblate spheroid, by the flattening of the Poles, and that cause forbade mountains rising at the Poles. It is necessary that we keep the above principles and facts in view as we proceed. The height of mountains, and seas open to the Poles are both causes of glaciation, and not to be overlooked, but cannot be cause of the continental ice-sheet.

Having stated the theory of the great glacial ice-sheet, and the facts upon which the glacialists place it, it seems expedient, considering how generally it has been accepted, to take yet closer and broader views of other facts and laws requisite to correct conclusions, many of them furnished by the glacialists themselves, but looked at by other eyes, these may afford proofs that should conduct to an opposite induction.

The *unstratified drift,* or boulder clay, or Till, is a chief argument for the continental Arctic sheet of ice. Grant it came from beneath ice, that fact does not prove that it came from a polar ice-sheet, for it might be from glaciers of contiguous mountains, or ices floating down from the North. Dr. Dawson say: "It may be viewed as consisting of a base or paste including angular and rounded fragments of rocks. The base varies from a stiff clay to loose sand, and its composition and color generally depend upon those of *the underlying and neighboring rocks.* Thus, over sandstones it is arenaceous, over shales argilaceous, and over conglomerates and hard slates, pebbly or shingly. The greater number of the stones contained in the drift are usually like the paste containing them, derived from the neighboring rock formations." Acadian Geology, 59. In Brazil it is "ochraceous, highly ferruginous, sandy clay." Agassiz, 399. This is evidence that the source of the Till is local and co-extensive with a local cause and source; but as the Andes are of immense height and running the length of South America and covered by perpetual glaciers, so the manufacture of the paste is present through all time; and the frosts and rains have ever since the Cordilleras were raised, spread it over the declining surface towards and to the Atlantic. With this eternal winter ever present upon the Andes, even under the Equator, it does not seem necessary that we should seek a cause in a great "cosmic winter," "of universal cold," which may have lasted "for thousands of centuries," for so much Agassiz says. We need not then go to a polar ice-cap for an explanation. The Till may be there from normal causes, and thus be yet spreading over the surface.

Agassiz rejects the idea of deposition under the sea, because there are no marine remains in the strata of rocks or their covering. He says: "It is my belief that all these deposits belong to the Ice Period in its earlier or later phases, and to this cosmic winter, which, judging from all the phenomena connected with it, may have lasted for thousands of centuries, we must look for the key to the geological history of the Amazonian Valley. I am aware that this suggestion will appear extravagant, but is it, after all, so improbable, when Central Europe was covered with ice thousands of

feet thick ; when the glaciers of Great Britain ploughed into the sea, and when those of the Swiss Mountains had ten times their present altitude ; when every lake in Northern Italy was filled with ice, and these frozen masses extended even into Northern Africa ; when a sheet of ice, reaching nearly to the summit of Mount Washington * * (that is, having a *thickness* of nearly six thousand feet,) moved over the *continent* of North America ; is it so improbable that, in this epoch of *universal cold*, the Valley of the Amazons also had its glacier poured down into it from the accumulations of snow in the Cordilleras, and swollen laterally by the tributary glaciers descending from the table lands of Guiana and Brazil? The movement of the immense glacier must have been eastward, determined as well by the vast reservoirs of snows in the Andes as by the direction of the valley itself. It must have ploughed the valley bottom over and over again, grinding all the materials beneath it to a fine powder, or reducing them to small pebbles ; and it must have accumulated at its lower end a moraine of proportions as gigantic as its own ; thus building a colossal sea wall across the valley." p. 425. But he found no striated stone as there was no natural rock-surface in the valley; and admits "I have not here the positive evidence which has guided me in my previous glacial investigations." p. 426.

All this account of the Amazonian Valley is inconsistent with what Mr. Agassiz had, in the same Journal, 403, said of a Northern and Southern Ice-cap "moving to the Equator," and with all the other glacialists who claim that it did not descend below the thirty-ninth degree of latitude. This gigantic glacier certainly did not come from the South Pole ; nay, when in the stage of thawing, it did not move at all. It was dammed in by its own moraine or huge wall of *débris* ; and when it melted it became a vast fresh-water lake. And Agassiz says : "In this shallow sheet of water under the ice, and protected by it from any violent disturbance, those finer triturated materials always found at a glacier bottom, and ground sometimes to powder by its action, would be deposited and gradually transformed from an unstratified paste containing the finest sand and mud, together with coarse pebbles and gravel, into a regularly stratified formation." Ib. 428. This is said to explain why this is not like the same glacial product in Europe ; why it is stratified as a deposit of still waters, but does not explain how the same material has a different appearance over the general surface of Brazil ; how the trituration and stratification would go on without motion of both ice and water, nor what, during such quiet lake-like operation under ice, had become of the floods that were ever descending from the greatest water shed of the world which must reach the sea. The attempted theory demands too much, involves difficulties not cleared up, and stands upon another basis than that of polar glaciation. That the floods of the Amazon and all its tributaries should be self-dammed into a lake of fresh water, and, at near the sea level, covered with ice under the equator is a proposition that seems of the most extraordinary nature, and self-condemning.

Let us proceed to examine other witnesses for additional facts, and compare other opinions of the scientific experts, though it be to find them expressing conflicting views, as they are wont to do in courts of justice, when it becomes the duty of the judge to extract the truth as well as he can, by principles of reason applied by good sense. The testimony will keep in view not only the facts of glaciation, but also those which show that there were other causes for all the phenomena we witness less abnormal than that assigned by the eminent naturalist whose name gave authority to all his utterances. If a continental ice-sheet of the magnitude supposed could not travel hither from the North Pole by land, there may have been water-ways for ice to float down from the Arctic region, and also local glaciers from higher mountains where none are now to be found, or those of much smaller size.

If the glaciation was cosmic, polar and continental, then should Northern Asia bear evidence of it. James Geikie claims to include North America, but does not claim Siberia as having been subject to the reign of ice. He says: "Thus, in the Western as in the Eastern Hemisphere, we are confronted with precisely the same phenomena. In regions which can be proved never to have been over-ridden by the great continental glaciers, and in districts which give no evidence of submergence during the latest period of glacial cold, the extinct mammalia occur in less or greater abundance at the very surface." Great Ice Age, 501. He further says the north coast of Asia "indicates the former presence of a milder climate in Siberia than now," "in the presence of numerous animal remains," as of the "mammoth, wooly rhinoceros, bison and horse." p. 495, 496. "The great plains of Siberia never could have nourished glaciers." "The absence of high grounds, and the comparative dryness of the climate, must have prevented any accumulation of glacier ice." 502. And he only claims that the great glaciers extended southward to the middle of England. Yet to fill the conception of Agassiz and Croll the ice formation at the North Pole should have so filled the Arctic Ocean as to move by its weight over the land of Northern Asia, as well as over Europe and America. The land journey should have been the same over the three continents from the same mountain of ice at the North Pole.

Next to the boulder clay, the scratches and groovings in the rocks are taken as the proofs of the Polar ice-sheet. Their straight northerly direction affords the argument.

Dr. Dawson, an eminent practical geologist, who has observed by travel and reflected much upon the subject, rejects the theory of the great ice-sheet from the far north. The scratchings are not from one direction, but some from nearly north, some from north 20° and 30° east, north 20°, 25°, 30° and 65° west. Acadian Geo. 62; 69. In the St. Lawrence Valley the direction is from northeast to southwest. At Stony Point, Lake Erie, Michigan, the grooves are from north 60° east, and from north 60° west. Winchell, 218. Dana gives greater variations, showing variations and hitches in the moving mass. 539, 751. And Henry D. Rogers said, the

grooves crossed at various angles, and "the striæ are, moreover, not rigorously straight, but curve slightly to conform to inequalities in the shape and hardness of the resisting surface." 2 Geo. of Penna., 775.

Dr. Dawson says: "I have no hesitation in asserting, from my own observations as well as from those of others, that for the southwest striation the direction was *from the ocean toward the interior*, against the slope of the St. Lawrence Valley. The crag-and-tail forms of all our isolated hills, and the direction of the transport of boulders carried from them show throughout Canada the movement was from northeast to southwest. This at once disposes of the glacier theory for the prevailing set of striæ, for we cannot suppose a glacier moving from the Atlantic up into the interior. On the other hand, it is eminently favorable to the idea of ocean drift." 69. This was based upon the idea of a submergence of Canada, New York, and New England, and an Arctic current bearing ice in the forms there produced. He proceeds to say: "Now we know that in the Post-pliocene Period, Eastern America was submerged, and consequently the striation at once comes into harmony with other geological facts." 70.

Dr. Edward Hitchcock, in his address in 1841, says: "The group named post-tertiary by Mr. Lyell, is found also in the northern part of New York and in Canada, containing shells of a more Arctic character than those now living in the same latitudes." p. 18. To produce the drift, scratchings, and transportation of boulders witnessed, the agents must have been water and ice, exerted before the existence of man on the continent; yet geologically recent; but he did not pronounce his belief in the great ice-sheet. 22, 23.

Professor Rogers says: "From the coast of Maine westward to the basin of Lake Ontario, and from the estuary of the Hudson northward to that of the St. Lawrence, a deposit of blue clay and sand occupies the valleys of many of the rivers at all levels above the tide and to a height of more than four hundred feet in the Valley of Lake Champlain, where its elevation is at its maximum." And speaking of the later local drift, he says: "No one general direction or northern source can be assigned to this upper deposit, *its gravel and erratic blocks appearing rather to be derived from the more ancient general drift of the adjoining hills, redispersed by some aqueous movement upon the surface of the fossiliferous clays and sands.*" 2 Geo. of Pa., 775.

To proceed with our survey geographically from east to west. The Geology of New Jersey by George H. Cook presents us with some relevant information. He says: "After the process of deposition had ceased, the whole of this ancient shore has been elevated to nearly four hundred feet above the ocean level. This has taken place bodily." But, "Some powerful agency like that of water, or water and ice, has swept over the whole country, and has worn down its surface in gullies, valleys, or broader intervals, sometimes to the amount of three or four hundred feet." p. 285. He gives twenty-four observations of scratches on the Traprocks. Of seven on the Palisades their course is south 20 to 40 degrees east; Bergen

Neck southwest and southeast; south and west of Patterson south 60 to 75 degrees west; Second Mountain and Rook Mountain southwest and 15 to 65 degrees west. p. 228. "The stones and boulders are in many cases from distant localities," those containing fossils are found in place only on the northwest side of Kittatinny Mountain. 229. "Two skulls of the walrus, an animal living only in the polar seas, have been found in the gravel near Long Branch." p. 342. These were, no doubt, ice borne; the question is whether by floating or creeping ice? Parts of South Carolina has undergone a similar denudation of one hundred and fifty feet. Tuomey's Gel. Rept. 102. All these are evidences of the doings of ice, and of currents of water from the northward, and not of the rigid movement, and grinding, leveling power of a gigantic ice-sheet.

British America, north of and including Canada, is generally a plane; its lakes being from three hundred to eight hundred feet in height; and the chain of great lakes bounding the United States are from two hundred and thirty-two to six hundred feet, the height of Lake Superior; so that the rise between Quebec and the west end of that lake, twelve hundred miles, averages six inches a mile. Survey of Canada, 1863, p. 6, 7. A table of one hundred and forty-five glacial grooves is given in the Survey of Canada, with a general southern direction, p. 890, of which eighty-four range west of south, some of them from 45 to 76 degrees, and fifty-seven range eastward, some of them from 45 to 80 degrees, or approaching an east and west direction. These are in Southern Canada, below 50°36′ of north latitude. Along the Ottawa the furrows conform in a general way to the direction of the river valleys, the limits of which appear to have guided the moving masses producing the present grooves." Ib. 889.

The superficial deposits in the vicinity of Montreal show former sea margins at the heights of 470, 440, 386, and 220 feet over the sea level. Dr. Dawson, Geol. Report of 1863, p. 918. Below the lowest level and about one hundred feet above the St. Lawrence, or one hundred and twenty above the sea, are the stratified deposits of gravel and fine-grained sand; then comes a calcareous gray sand, which rests upon the boulder clay, which is filled with rounded and striated fragments of various rocks, all of the thickness of about one hundred feet, of which the boulder formation is the greater part. The rocks beneath are polished and grooved. The boulders were drifted southwestward, and came from 40° to 70° east of north. Ib. —. Yet, towards the mouth of the St. Lawrence, a Gaspé boulder of limestone, 40 feet in diameter, has been moved several miles north or northeastward, and blocks of granite from Table-topped Mountain down Magdalen Valley several miles northeastward. Dr. Dawson described similar instances of northward transportation of boulders in Nova Scotia. Ib. 803. The White Mountains were at long distance of time twice elevated, first by a force from north 80° west, then from south 10° east, which indicates the thrusts of oceanic depressions from the west as well as from the Atlantic. See C. H. Hitchcock's Rep. to N. Ham. Leg. for 1871, p. 9. It is thus seen that Canada as well as New England and the Mississippi

Valley rose from the ocean, and at different elevations the abraiding ice had different directions.

By the Ohio Geol. Survey, vol. i, p. 538, it appears that of the striæ across the islands in the west end of Lake Erie and in the Maumee Valley, sixteen observations in eight counties, have a bearing south 80° west to 35° west with two intersecting grooves south 15° west. At West Sister Island the glacier moves westward, the pressure and planing being greatest at the east front, while on the opposite shore the undulating surface of the rock has been merely scratched. p. 539. The limestone rocks of that island contained imbedded flint nodules, which offered a greater resistance to the ice. On the "lee" side of each is a long ridge in the limestone by reason of the protection of the hard flint. This phenomenon, says Mr. Gilbert, "seems to afford a better explanation of the long, smooth, even furrows so frequently seen, than the theory that they have been engraved or ploughed by large boulders;" p. 540; that is to say, the rocks were ground by the ice.

Dr. Newberry describes the drift deposits of Ohio, and as to the lowest says, the "sheet of clay and boulders I have termed the Glacial Drift because it seems to be the direct product of glacial action." p. 86. Scattered over the drifts are numerous boulders, often of great size. They must have "been floated to and dropped upon their present resting places. In my judgment no other agent than *floating ice* could have accomplished their transport in the manner in which it has been done. Hence, I have considered them as the result of iceberg action, and have termed them and the northern gravel with which they are associated, the *Iceberg Drift.*" 87, 183; 2 vol. 4.

Pursuing the Ohio Survey into the second volume of 1874, Dr. J. S. Newberry gives many pertinent observations and reflections: "In Ohio we have no geological formations intervening between the Carboniferous and the Quaternary." The reason, "about the close of the Carboniferous Age the Allegheny Mountains were raised, carrying up all the area lying between the Mississippi and the Atlantic. From that time to the Quaternary no part of this region, with the exception of the southern margin, was ever submerged." "West of the Mississippi the land has been often and long below the ocean level since the epoch of the coal measures." "The materials which accumulated during the Quaternary are beds of clay, sand, gravel, and boulders, which have received the name of *Drift.*" "The drift deposits cover nearly all parts of the State." p. 1. He holds that the rocks were planed down to latitude 40 by glacial action. p. 2. The lowest drift deposit, "though not always present, is a tough, blue, unstratified clay, generally thickly set with small stones; more rarely containing those of larger size, ground and scratched;" hence, called the boulder clay. "In certain localities the pebbly 'hard-pan;' or boulder clay, is overlaid by a greater or less thickness of fine laminated clay, without pebbles;" and these blend so as to leave no line of demarcation, and together are called *Erie clay.* Above is the *Forest Bed.* p. 3. "In Western Ohio, In-

diana, Illinois, &c., the uppermost strata of the drift is called the Loess or Bluff formation." These "are the products of the last submergence, and I have termed them the *Lacustrine* Drift." Upon these "are scattered boulders and blocks of all sizes of granite, greenstone, silicious and mica slates, &c., &c., &c., generally traceable to some locality in the Eozoic area north of the lakes." "The boulders are found on nearly all the drift-covered area of the State; being carried over the summit of the water-shed, and reaching south nearly or quite to the Ohio. The margin of the boulder area seems to mark the outline of the great ice-sheet at the period of its greatest development; but *most of the boulders* strewed over this area, *appear to have been deposited by another agency*, at a much later date." They lie near the surface, often over purely laminated clay, "and hence could never have reached their present positions through the agency of glaciers or powerful currents of water. They must, therefore, have been *floated* to their present resting places. The evidence is conclusive that they were transported by icebergs, and hence I have called them the *Iceberg Drift.*" p. 4.

Dr. Newberry gives 87 observations of a system of grooves confined to the lake basin and the northwestern counties of the State, from which he says "the prevailing direction of the stria is 10° south of west," and remarks "that in this portion of the State a series of glacial marks which have a nearly north and south bearing, are obliterated by the stronger, fresher, and more numerous grooves of which the bearing is nearly east and west. As I have shown elsewhere, the striæ which cover the highlands and southern portions of the State were probably made by the continental glacier which existed during the period of greatest cold, and which had in Ohio a movement from north toward south and southeast; while the glacier which moved from east westward in the lake basin was a *local glacier of later date*, and the one by which the excavation of the lake basin was principally effected." 2 Ohio, R. 10.

"It seems that in the period of greatest submergence the larger part of the summit of the water-shed was under water." "At this time a sufficient depth of water existed in the passes of the water-shed to float icebergs of considerable size, and as currents flowed through these passes, some of the boulders scattered over Southern Ohio were probably transported by them." Five of these passes are noticed; marked "by deeply excavated channels, now more or less perfectly by great accumulations of rolled and transported material, such as would be the natural product of a copious flow of water, continued through ages of time, and gradually diminishing and losing its transporting power." p. 47. These out-lets carried the waters southwestward into the seas or lakes of the great Mississippi valley. The Niagara River and Falls then were not. p. 52.

"The boulders belong almost without exception to the chrystaline and igneous rocks that are found *in situ* only to the north of the great lakes." p. 26. None are from east Canada or Labrador; but nearly all "can be traced to places of origin in localities north and northwest of Ohio." p. 27.

An inquiry here arises that if floating ice must have been the cause of all the drift and erratics, why should not the same cause have produced the boulder clay? The floating ice could as well do it, as it ground over the ledges of rocks, as an Arctic glacier and the water could better spread the clay as it is found. Such a supposition would obviate a resort to the great ice-sheet for explanation, and avoid other difficulties to be noticed. It is certainly an immense conception of an abnormal cause to explain a limited effect, that seems to have already had its sufficient and acknowledged solution in the cause of every other stratum of the drift.

It is said by Dr. Newberry (2 Ohio Rep. 29), "That the boulder clay was not deposited *beneath* the glacier, as sometimes stated, is apparent from the fact that it covers the glaciated surface on which the ice rested, in a sheet sometimes a hundred feet in thickness. *It must, therefore, have accumulated at the margin of the glacier.*" As the boulder clay is very widely spread, as well as often of a great depth, the more natural inference would seem to be that it was spread by the waters, as ground from the rocks by floating ice-rafts, and afterwards yet more dispersed by the ocean currents. But the witnesses do not always agree with themselves or with each other upon this subject.

The 2 Volume of Ohio Rep. in its Chapter L., contains views at variance with the theory of "the glacier," contributed by Mr. E. B. Andrews. He says Professor Hopkins expresses the belief that the boulders found on highlands of the 2d Geological district, were transported by floating ice-rafts, "and not by a vast, continuous northern glacier," and that drift materials were carried down to the lower Mississippi district. And Professor Hilgard thinks that "the phenomena observed in the Southern States are but the necessary consequences and complements of the drift phenomena of the North," and says it is time "that the Ohio should cease to be proclaimed as the southern limit of the drift." p. 451. Mr. Andrews speaking of the southeastern part of Ohio says, we have seen "there is no evidence that the pre-glacial or ante-drift surface *was essentially different from what it now is.* If there was a climate so arctic in character as to allow of the extension of a sheet of ice immensely thick almost to the Ohio River, we should expect that the same cold climate would necessitate glaciation in the Allegheny Mountains, but a short distance south of the Ohio, where no traces of glaciers have been found. The average altitude of the Allegheny range is 3,000 feet. If, on the other hand, the cold were produced by marine currents coming down from the Arctic region, it would have the sharp limitations characteristic of such currents at the present day." "Local glaciers are freely admitted to have existed on the higher grounds adjacent to the icy northern currents." p. 449. Mr. Andrews quotes the strong views of the Duke of Argyle, President of the Geological Society of London, against the glacial sheet, as satisfactory. p. 450.

In the Geological Survey of Illinois, of 1873, the northwestern section is described by James Shaw. He says, "That vast glaciers of ice once extended over large portions of North America is now universally conceded.

Their slow, crawling motion and irresistible force ground the rocks to powder, as wheat is ground to flour between the upper and nether mill-stones; not only ground them to powder, but rounded and polished the boulders and the gravel, planed and grooved the rocky surface of the earth, and moved the vast masses of drift materials from place to place in slow procession." 5–6. "But the great mixing and transporting agency which arranged, assorted, and deposited our Northern Illinois drift deposit, was evidently *the mixed action of ice and water.*" 6. The first and greatest force was the glaciers of the high lands; "then the floating iceberg and ice-field produced by their results, carrying the large boulders from place to place, and dropping them over the ice-cold seas; and last, the wave and current forces of water, after the ice had in part, or altogether melted, left loose clays, sands and subsoils, substantially as we find them now." 6–7. "Eroding and denuding influences have removed from three hundred to three hundred and fifty feet of Magnesian limestone and shales." "The dynamical powers of heavy bodies of water and water currents, and other drift forces, must have acted long and powerfully in bringing them about." 31, and see 32. "A mixed mass of gravel * * would seem to indicate that forces from a distance and forces near at hand, operating in every conceivable direction, with great force and over long periods of time, all contributed to gather together these heaps of abraided materials, some from the distant regions of the granite and the traps, and some from the neighboring limestones of a bygone geological age; but all equally worn smooth by the grinding of the waters and ice." 109. "Whether the floating iceberg, or the slow crawling glacier, or the strong water currents, or all these combined, transported the coarser materials of the drift, the force of the powerful agents were much modified in their action here." 145. It would seem that the other powerful causes stated, might suffice, if "the slow crawling glacier were omitted; and this is the opinion of Mr. E. B. Andrews; assistant in the Ohio Survey, 2 Vol. 447. He says, "There is no general planing off of the rocks; but everywhere among the hills where the northern boulders are most abundant are projecting knobs or outliers of soft rocks, which would naturally be an easy prey to such a destructive force as would be exerted by the movement of a vast glacier." 448.

Moving westward we reach Wisconsin, Iowa and Minnesota, upon which David Dale Owen made his Geological Report, to the U. S. Government in 1852. Among the materials of the drift the "trappean rocks are much the most common." "They originated at the time of the upheaval of the trap, and at comparatively a recent period. There are facts ascertained which render it probable that a large area of the Northwest Territory has been raised during very modern periods, even since the present fauna inhabited its rivers and lakes." "There is a gradual drainage of its waters taking place, even at this time." p. 143.

"In the vast prairie region of Iowa, the attention of the geologist is frequently arrested by erratic blocks of enormous dimensions, scattered here and there, and half sunk in the ground." "They are far from their

original situation." "The only explanation that is at all satisfactory in accounting for the transporting power which has brought detached masses of granite rocks into their present position, *is floating ice*; ice drifted by currents setting from the north, before the land emerged from the ocean, in the same manner as, at the present time, thousands of tons of rocks are precipitated on the bed of the Atlantic Ocean from icebergs." "Their isolated position in the prairie also indicates that they were dropped into their present positions rather than rolled into it." 144, 145. "The clay-beds are often thinly laminated, at some exposures, the laminæ are wrinkled. They conform in their dip to the general undulations of the country." p. 298. This, of course was after the depositions.

Charles A. White's first annual Report in 1867, to the Iowa Legislature, speaks of meeting with some striæ on the bluffs which border the bottom lands of the Missouri River; the coarser set (No. 1), S. 20° E.; the finer (No. 2) S. 51° E. Set 3 below Omaha is S. 41° W. p. 144. The direction of the scratches No. 3 observed coincides pretty nearly with general direction of the western watershed of the State; "and sets No. 1 and 2 respectively represents currents approximately coinciding with the general courses of the Missouri and Platte Rivers." p. 145. Diversity in the direction of the grooves, passing from all northerly to all southerly points, and in conformity with the trend of valleys and water-sheds, favor the theory of the cause being floating ice rather than the rigid gigantic ice-sheet that would hold its course onward against all obstructions, according to the glacial theory.

Professor Hayden has occasionally noticed the action of ice during his recent explorations in the far west, but the striations have been mostly from the valley glaciers in the mountains. He says: "Along the Platte River, below Omaha, and on the Missouri, near the city, the carboniferous limestones have had their upper surface so thoroughly smoothed by glacial action that they can be quarried out and used for caps and sills without any further finish of them." Report for 1870, p. 99. "There are a few small grooves or scratches, and * * I ascertained their direction to be about 27° west of north." All the limestones round Omaha, under the yellow marl and pebble deposits, were so smoothed. "In the mountains proper, the evidences of glacial action are not uncommon, especially on the sides of the deep valleys and gorges, but the causes were local and operated when the temperature of the climate was much lower than it is at present." p. 100.

Speaking of the eastern portion of the Rocky Mountains, source of the Arkansas, Professor Hayden says: "Perhaps the most interesting and novel features of this region are the great morainal deposits, the remains of ancient glaciers. These proofs of glacial action occur everywhere along both the east and west sides of the great Sawatch or Mother Range. But up the valleys of some of the side streams the morainal deposits are more marked and regular than in others." Report for 1873. Speaking of the Park Range, the gentle slopes are on the east side, the west sides very

abrupt, sometimes the rocks overhanging indicating that they are a portion of an anticlinal. Ib. 39. So our Appalachians and Atlantic seaboard hills lean from the Atlantic Synclinal, as if the upheaving force was in the sinking bed of that ocean, or as one preponderated in the balance the other rose.

One other great feature of structural geology is to be noticed in these Reports. The mountains are built of granite, gneiss, &c. From the Mississippi and Missouri to the Rocky Mountains the stratified deposits of sandstones, limestones, shales, slates, and clays, lie in flat broad sheets, "much as they were when first laid down, one after another in the *bottom of the vast ocean which once existed here.* Since this ocean was gradually drained off, the ceaseless action of the rains and rivers has in places removed thousands of feet of these rocks, exposing beds which were once deeply buried, and in which we can occasionally find the remains of shell-covered beings which still earlier lived and died upon the ocean bottom, or of the skeletons of the animals and plants which peopled the surrounding shores, and were swept by the ancient rivers out into the sea to be buried with the then forming sediments." Dr. Hayden's Report for 1873, p. 93.

And Dr. Newberry, in the United States Report for 1870, says of the lakes that once occupied the region immediately east of the Rocky Mountains: "The sediments that accumulated in the bottoms of these old lakes show that in the earliest periods of their history they contained salt water, at least the sea had access to them, and their waters were more or less impregnated with salt, so as to be inhabited by oysters and other marine or estuary mollusks. "In due time the continental elevation which brought all the country west of the Mississippi up out of the wide-spread cretaceous sea, raised these lake basins altogether above the sea level, and surrounded them with a broad expanse of dry land." p. 329.

But how came such "continental elevation?" Not alone by lifting up the continent bodily, else would the marine deposits have remained at the top and the waters have been drained off, carrying off largely its deposits; but must have been largely raised up by the degradation of higher lands or mountains by freezing, thawing, and erosions, and the flow of the materials into the basin of such sea and lakes, thus preserving both the salt and the fresh water fossils found there in "wonderful" abundance. So were Ohio, Indiana, and Illinois, filled and raised up, and hence, old river bottoms are found far beneath the present surface. And the stratified rocks thus formed have been since cut down into cañons, and even the granites also; all disintegrated both by frosts, heats, and erosive waters, and ice, as well as chiseled by "sand blasts." Hence are there many rocks left perched in the west as in the east, that have never been lifted, or floated by ice, but have simply held their positions after the surrounding strata had been carried away by the above named dynamic causes.

Dr. Newberry further testifies that, "In the progress of the Cretaceous Age, the greater part of the continent west of the Mississippi sank beneath the ocean, and the deposits made during the later portions of the Cretaceous

Age, contain a vegetation more tropical in character than that which preceded it. It seems probable that at this time the lands which existed as such at the west of the Mississippi, were islands of limited extent, washed by the Gulf Stream, which apparently had a course north and west from the Gulf of Mexico to the Arctic Sea." Prof. Hayden's Geological Survey of Wyoming, &c., for 1870, p. 336. It will not be forgotten that the tropical vegetation spoken of, was due to the warmth of the Gulf waters flowing to the northwestward, and perhaps, the Earth's interior heat, yet unradiated.

As by the discrimination made in the west by which all the drift above the boulder clay is ascribed to *floating ice*, so by the same rule the sand and boulders of New England should be ascribed to the same cause. They should be regarded as water-rolled and water-borne in ice rafts as they appear to have been, when existing mountains there were at different heights, and where the lower ridges were not so high nor the valleys so deep as now, and all but the highest mountains were under water, so that the excoriations would be the more continuous, and the rocks lifted from one ridge be carried upon another or dropped intermediately ; reaching Long Island and the sea, or let fall at Stonington, or in the Sound and bays. Thus they might have been carried to ridges now higher, without violating the law of gravitation, as the latter may have risen disproportionately, as did the White Mountains compared with the Green. In Ohio, Indiana, and Illinois, they had not such mountains to guage the rise of the land as in New England, by the water level, as shown by the grooves of transported ice, but the water at the west left the proofs that it was the agent that shaped the surface of the country more perfectly than the ice-sheet would have done. Dr. Newberry speaking of the five gorges in Ohio, that gave outlets to the water towards the southwest, says : "Each of these gorges is now more or less filled with drift, but the remarkable similarity of level which they present will strike the most casual observer, and will not fail to suggest their reference to *a common producing cause*. All the lines of drainage leading southward from these passes are marked by deeply excavated channels, now more or less perfectly filled by great accumulations of *rolled and transported material*, such as would be the natural product of a copious flow of water continued through ages of time, and gradually diminishing and losing its transporting power." 2 Ohio Rep. p. 47.

Dr. Newberry speaks of repeated vertical oscillations of the surface: says, "The withdrawal of the water of the last submergence of the drift took place slowly, and its progress was marked by periods of rest, and perhaps, of recession ;" hence, the *Terrace Epoch*. Ib. 50. The ice period was one of an elevation of several hundred feet. It was followed by a water period and warmth ; the continent five hundred feet below the water level. The first deposit of this period was the boulder clay. p. 6. This would seem to make it a deposit under water. Then came the laminated clays, on this came the forest and peat beds, which of course grew in the air. After these may have grown for hundreds or thousands of years, a submergence

of the continent took place. During this, the *clays, sand, and gravel were deposited; floated down by icebergs from the Canadian highlands*, with blocks of granite, greenstone, slates. See p. 7. Yet "the glacier" is credited with having carried large blocks of lime and sandstones "one hundred miles or more southwest to points several hundred feet above their place of origin," from the north or islands within Lake Erie. p. 29. In view of all the circumstances it would seem more natural to infer that these large stones were transported by floating ice-rafts and deposited on ground that was *afterwards elevated*, as it often was by an interior force.

Again, Dr. Newberry says: "At the commencement of this ice period this continent must have stood several hundred feet higher than now." 2 Ohio Geo. Rep. 6. That the first product in Ohio of the ice period, was the boulder clay. And that in New England and other countries where granite and other silicious matamorphic rocks abound, the product of glacial erosion is sand, gravel, and boulders. As the great ice sheet retreated northward it thrust out and left behind it a succession of heaps of boulder clay which now form a nearly continuous sheet over the glaciated surface," Ib. These quotations present some difficulties. If the continent was several hundred feet higher at the commencement of the ice period than now, so much greater would have been the difficulty for ice to come hither from the Pole by land; whereas if it was then under water, as under the next coming drift period, such a rise was unnecessary to account for the Till which might be the product of floating ice; that would also dispense with Mr. Winchell's mountain at the Pole to make an incline for the ice to come down by gravity. And, again, it is not perceived how a northwardly retreating ice-sheet, that is, retreating only because and as it melted, could have *thrust out* and left behind it the boulder clay, bearing all the evidences of having been spread out and deposited under the action of pervasive waters. Indeed, Dr. Newberry seems to have raised the continent once oftener than necessary, if the boulder clay could have been deposited under the sea as he admits the drift and many boulders were.

Now, seeing from all the testimony cited, that Canada and all directly to the north, was under the ocean; New England also, except the highest tops of the mountains; and the great Mississippi Valley was also an extension of the Gulf of Mexico; that there were no great Mountains northwards of Canada, nor in Canada, but an ocean current bore thence southward dividing southeastward over New England, and westward and southwestward over the country lying between the Rocky Mountains and the Alleghanies, what is so likely to have been the source of the Till, the boulders, the drift, and rock groovings as the northern ice borne upon the northern oceanic currents? There may have been icebergs broken from Arctic Mountain glaciers, and other ice formations; all floating as ice rafts, thick and of irresistible momentum, grinding upon ridges yet under water and carrying their materials southward.

In view of the preceding facts it seems sufficing to say, that when New England, the Hudson and Champlain Valleys, Canada and the British

Possessions, Ohio and states west and southwestward were under water, and the currents and ices of the Artic Ocean had full sweep over those areas, we have the conditions to account for all the phenomena witnessed. without resorting to the extremely abnormal cause of a continental ice-sheet. The depression of New England Professor Winchell speaks of in this wise: "The higher summits only held their heads above the careering waves; deposits, bearing the marks of oceanic action reach to an elevation of six thousand feet on Mount Washington, two thousand or more on the Green Mountains, and three thousand on Monadnock." p. 229. If these measurements had the same sea-datum then their differences record the differences of the mountain depressions, or rather the elevations they had then attained. The same height on Mount Washington is that given by Agassiz as the highest elevation of the ice excoriation; Journey, 425; and that being the greatest ocean height, the conclusion is clear, that it was the edge of ice-sheets that made them, and these could only be floating ice; certainly not stones in the bottom of a continental ice sheet. The inference must further be that as the sea thus registered the greatest depression, or want of elevation of *each* mountain, Mount Washington had been four thousand feet lower than the Green Mountains, and three thousand feet lower than Monadnock; so that there was such depth of water over the valleys and plains as that the Arctic Sea could flow over them, floating either ice-bergs, or belt, or surface rafts of ice. The land it was that was unstable, while the sea kept its level. The supposed gigantic ice sheet needed not to be fifteen or ten thousand feet, or so many hundred feet in thickness, to make those mountain grooves, when the mountains stooped nearly to the level of the sea, or their tops had but peered above the water. All were not equally low, otherwise the highest grooves in all would have had the same level. And so a continental ice-sheet moving on the land already elevated should have scored them at nearly the same level; in either way showing that the mountains had not been sunk equally, or that they had risen unequally. The submergence of New England, with an open interior sea to the pole certainly shows an easier way of accounting for the ice grooves upon the mountains, than to raise a land mountain at the north pole, and an ice-mountain upon the top of that, with a refrigeration to keep the sheet of the thickness of ten to fifteen thousand feet in the "Granite State."

While there are the ice grooves of New England and elsewhere to be accounted for; and these sharply cut, and geologically recent, there seem to be other things visible on the surface quite incompatible with the supposition of a continental glacier of the thickness imagined. The hills of New England, under such a power should have been more leveled down; for a glacier kept hardly frozen could not have much viscosity; it should have crushed the stones into the *moraine profonde*; should have carried few angular erratics, for the mountains to furnish them would be "few and far between," with comparative small elevation. But what do we see there? Huge boulders; rocking boulders; perched up rocks, that would not have been there after such a planing with the gigantic polar-ice plane; and a

surface covered with water-rounded stones of every size and kind, which had to be gathered into stone fences before the soil could be reached for cultivation ; yet so rounded are they that they readily roll out of place, though the base of the enclosure be broad. These are the natural product of a water-covered surface ; of waters floating ice ; which ice may have been thick as Greenland hummocks' ice-belt ice, or glacial icebergs, borne on the arctic current that now comes southward along the eastern side of our continent. We see the evidences that as the ocean retired, the elevation made successively of every part of New England a sea-lashed shore, leaving the drifts that the waters had spread over the sea bottom.

The glacialists seizing upon the one seemingly sufficing adequate cause of a great ice sheet, overlook the difficulties which that theory must encounter to account for that cause, and also other means that may more naturally account for the seen results, without resorting to any abnormal freak or eccentricity of Nature. They may notice that the grooves very generally conform to the trend of the high valleys and water-sheds and to the course of the currents when wide areas were beneath the sea ; denoting the descent of mountain glaciers, or the transportation by water of ice-rafts, or icebergs. They refer not to the transporting power of water in times of ice-floods, when mountain sides slid down, and lakes broke through their moraine dams. They take the presence of irregular boulders in the under clay of the drift as the sure evidence of the work of the polar ice-sheet, while the presence of the like boulders in all the drift, as we see here in Philadelphia, is not taken as proof that all the other strata of the drift had the like cause. The heavy boulders they see at a higher level than their parent place *in situ*, they suppose could only reach their elevations by being pushed up by the great continental ice-sheet because it must obey the pressure of the great ice-head at the pole, and approximating the level of that source of pressure, rises over the secondary mountains of New Hampshire, the Katahdin of Maine, and bridging sounds and inlets of the seas passes into the Atlantic. It is overlooked that those boulders may rest on elevations that may have risen out of the sea from a lower level than the parent quarry ; or may have been shoved higher by the back currents of water that will drive ice-sheets high upon each other when they encounter obstruction ; while on the other hand the ledges of rock that yielded the supply may have sunk lower, by the earth's oscillations, or have been ground down by floating ice, after higher rocks had been carried away.

It is said the glacial epoch was so recent that the mountains were already so degraded as to be near their present height when that epoch come on, and could not have been cause of the effects seen. Now the last glacial epoch is placed many thousand years ago ; Geikie says more than two hundred thousand years. We will not hold him to exact figures; but take it that was near the time, then it appears to have been ample for the mountains to become reduced from a much higher elevation than their present size, by the operation of normal causes, but anciently acting with greater activity. Now in every year since they rose the height of the

Alps has been lowered by causes that have never for one moment ceased; and yet more rapidly have the glaciers, which never ceased to flow, worn more deeply their channels. The striæ made by the ice on the sides of Monte Rosa and the Bernese Alps show that the glaciers moved at higher elevations relatively to the scored rocks, and adhering to the causes named, we must conclude that the mountains were higher and broader to increase the supply of snow, and that the glaciers moved upon a higher plane, whereby they scored higher tracings on the rocks, and projected further into the valleys below, and carried their boulders to a greater distance. These are causes sufficing for the visible effects, when we add to them to the transporting power of ice-bearing floods, carrying down land slides, and ice-covered lakes, which burst the dams that had sustained them. We need not go to the north pole or the planets to explain the phenomena of the Alps; except as icebergs floating down from the north would bring an arctic cold with them.

Lyell says "the Alps have acquired four thousand, and even in some places more than ten thousand feet of their present altitude since the commencement of the Eocene period." 1 Prin. 256. He speaks of what they *retain*; but what height they had at their greatest exaltation no one can tell, for upheaving elevation and disintegrating degradation are generally simultaneous proceedings; but from facts observed it seems more reasonable to infer that great glaciations were mainly local, except as arctic currents came down upon Central Europe freighted with ice.

Dr. Hector's statements lately made before the Geological Society in London, have a bearing upon several points of this discourse. The South Island of New Zealand has its Southern Alps of which Mount Cook, fourteen thousand feet high, is the highest, with a snow-field of one hundred and sixty square miles, in south latitude, nearly 44°. Judging by the moraine matter, snow formerly was vastly more abundant. He "demonstrated the excessive action of glaciers in cutting back cols; an action more energetic formerly; some of the cols having been worn down as low as eighteen hundred feet." "The reason for this contraction of the ice area is the great question for determination. Was it due to difference of climate, the result of a great glacial period? The remains of a past fauna afford no evidence of this. We may, indeed, suppose that the whole fauna migrated to the north; but we must, in that case *invent* the land and bring into play oscillations more extensive than those required for another alternative, viz:—the alteration of level, within the area itself. We might suppose a general alteration of level, even to the extent of four thousand feet higher than the present, but the evidence afforded by the shore line is unfavorable to this view. There remains the theory of *unequal elevation*, which combined with a most enormous destruction, the result of ages of glacier action, best explains the phenomenon." "In conclusion, the author stated his belief that there has been no general change of climate, but many changes of *relative level*, resulting in a great destruction of surface, which had taken place in groups of peaks at *different times*." Nature, January 27th 1876, p.

259. This statement is refreshing for its moderation and good sense. The isolation circumscribed the phenomena and forbade extraneous speculations.

Yet it is believed, that if we do look into general causes, and consider them well, we shall find that the forces of nature are so well balanced, that the imagined continental polar-ice sheet must be regarded as an impossibility; shall find that we need not raise mountains at the poles, against the effect of the force of the Earth's rotation, to slide down the ice; nor to submerge mountains and continents once elevated from the sea, again and again, to account for marine remains, or ice scratches upon the rocks, left there as they first emerged from the waters.

The theory of a north polar ice cap, spreading as a garment to the tropics, or to the fortieth degree of latitude only, seems not to have sufficiently considered the nature of the Arctic ice and climate. I open Dr. Kane's second Grinnell Expedition, and find that it wintered in Smith's Straits, latitude 78½°. In January the thermometer ranged from 64° to 75° below zero, Vol. 1, p. 154; from March 10th to 14th, the average was 46½° below zero. "The intense cold approximates all ice to granite." Vol. I, p. 184. Look at the pictures; the ice is as hard and sharp of outline as unworn rocks. p. 162. The glacier that has shed its iceberg presents a vertical front; The ice-belt between the "floe" and the land, is "24 feet in thickness, 65 in mean width; the second, or appended ice 38 feet wide; and the third 34 feet. All three are ridges of immense ice-tables, serried like the granite blocks of a rampart, and investing the rocks with a triple circumvallation." Ib. p. 162.

Dr. Newberry, 2 Ohio Rep. 70, cites Dr. Kane's account of a sheet of ice, eight feet thick, resting on supports twenty feet apart, as having swagged five feet midway of the supports, while the weather was far below freezing point, to prove that the polar ice-sheet could flow southward. To one not wedded to that glacial theory the evidence does not seem so strong. With the weight of its own bulk on the centre of a span of twenty feet, we might believe there was a perpendicular pressure much more than proportionable to the force that propels the Alpine glacier. Yet in several months the strain caused no fracture of the ice; no fluxion of particles to change its form; but all except the bend remained of the some shape, and sharp of outline. If it had rested on a plane of the inclination of the bed of the Alpine glacier, there is no indication that its mass or particles would have moved a hair's breadth. It will here not be forgotten that a polar ice-sheet to be thousands of feet thick in New England must be of growing thickness all the way to the pole, and that the intensity of cold for all that distance must have been greater than any Arctic cold known to us, and have held the ice formed in the water as firm as granite, and impervious to any heat that could reach it.

As to the snow that should fall upon land at a period of intense and long continued cold as supposed, it would not form into ice, or make the theoretical continental glacier. To make the ice of the moving glacier, there must be a back pressure from a greater elevation, and an *alternation of heat*

and cold; a thawing and regelation; so that climate may be too cold to make glaciers. Thus in Upper Thibet, on the north side of the Himalayas, the mean limit of perpetual snow is not only higher by more than a thousand feet than on the south side, but the belt of snow is narrower, the back pressure is less, and the snow deposited from the dry winds of Northern and Middle Asia are so dry as to make it questionable whether there are any proper glaciers, or anything more than the *névé*, or dry masses of snow in in layers. Reclus, 165–6; Professor Vogel, in Nature, March 16th, 1876, p. 394. Yet the snow there is seventeen thousand to nineteen thousand feet high, with a northern aspect.

Tyndall shews that ice is not viscous; will not stretch, but is brittle and will break under a strain, as when the glacier is compressed into a narrower channel; or must make a descent or curve; when the continuity is kept up by a back *pressure* and regelation; freezing then becoming an agency in wedging forward the mass in its shearing and descent. (Hours of Exercise on the Alps, 356, &c.) Yet under *pressure* it conforms to the valley and descends as if it were plastic. Ib. 358, 359, 401. To consider the difference between Tyndall and James D. Forbes, who held the theory of viscosity, is not now material. They both were dealing with the glacier in its cradle on the side of the Alps, having an inclination of four to five degrees, with a heavy incumbent pressure of the higher glacier, having a length of twenty or thirty miles, a width from two or three miles where widest; in one instance contracting from two thousand to 900 yards, with a depth sometimes of six hundred feet. Yet the downward flow was so slow as to require nice instrumental means to detect it, and though variable, owing to the difference of inclination, or choking of gorges, the figures for the day of twenty-four hours, most usually found are from twelve to twenty inches. 1 Lyell, 365, 366, 367. The flow is slower in winter than summer, and faster at the centre than the sides, and at the top than at the bottom.

It is apparent that the circumstances are not parallel with the supposed ice-cap at the North Pole. The existing testimony is, that this is an open sea; and if not that, is an ice covered sea, without land. There is not even level lowland for the ice to form upon. There is no mountain to bring the force of gravitation into operation. The ice that could saddle the pole could have no tendency to move in any direction, for there is no inclined plane. The hard frozen ice would not be borne downward by the weight of higher ice; nor crevices be filled by regelation, thus to wedge forward the frozen mass, as in high mountain regions. Greenland is a ridge of three thousand to four thousand feet elevation, and that will make glaciers in the valleys. But the supply of ice thence, or from Grinnell Land, or Labrador, to reach Europe, must have been *floating* masses; and so as to the interior of our country, if they came so far.

Ice is, in another respect, less likely to descend by land to a lower latitude from the pole, than if resting on a solid plane. Though the ice at a very low temperature would not melt in the air, yet, *resting on the water* it would become *sodden*, rot and sink; and without land support could not

rise to a height to spread the mass outward by its *own* fluidity, or any pressure of impending weight of ice. The point of least resistance would be the sodden ice and water beneath. The fresh ice contains no salt ; the "water sodden," is "thoroughly infiltrated with salt-water." 1st Kane's Grinnell Expedition, 96. Captain Richard Wells, commanding the whale Ship Arctic, wrote to Mr. Grinnell, June 18, 1867, that he had steamed up Smith's Sound to about 79° of latitude; found the ice "rotten and very much decayed, the ship steaming easily through rotten floes. The ice on the east side, excepting in Whale Sound, appeared to have decayed away and parted from the land as far as the glass would carry, and would offer no impediment to the progress of any steam whaler. A poor foundation this, upon which to build a mountain of ice.

And consider also the geography of the Arctic region as to the proportion of sea and land, and the interposing elevations of the land. Remember, also, that the earth's features at the supposed glacial period were in outline the same as now. A polar ice-sheet to cover North America and Northern Europe must have filled the ocean to the bottom and risen to a height far above the sea to compel the ice to move by pressure southward to the 39th or 40th degree. We need not estimate what that height must be, when we know it would have no land basis to rest upon ; and know also that intermediate mountains, indeed all land, would be obstructive of progress instead of sources of power. In Europe, such a polar ice-sheet must have filled the Arctic Sea, and risen from its bottom over the mountains of Norway, Sweden and Scotland. In North America it must have risen over the mountains of Grinnell Land, that of Greenland, and the Labrador and Laurentian ranges, and crossed the St. Lawrence River. But glaciers under pressure would sooner squeeze through a gorge, as two thousand yards in width will pass through a defile of nine hundred yards in the Alps. The channel of the Atlantic would be preferred to the elevated land to travel southward across fifty degrees of latitude by land. The continental ice-sheet would have been a glacier in the Atlantic. That the north polar sea is open, is not only proved by men who have looked upon it, but Dr. Scorsby testified that the "Right Whale" that always shuns the tropics, has carried the marked harpoon from Baffin's Bay, through Behring's Strait, into the Pacific ; and the whale must breathe the air He could not cross the equator, nor go under ice into the Pacific, Maury's Ph. Geog. of the Sea, Sec. 144. The birds go to the north of Greenland to breed because there they find their food in an open sea ; and we know that northwest of this continent the Arctic Ocean extends down to the seventieth degree of latitude.

Again : Concede the extreme glacialists solid land at the pole for the ice-cap to rest upon ; yet consider the enormous demand made upon our credulity to meet the conditions of their theory. The ice-sheet is to be from ten to fifteen thousand feet thick in New Hampshire, according to Agassiz : It is to reach the fortieth degree of north latitude according to several other glacialists. To give it the pressure by gravitation of the glaciers

of the Alps it must rest upon an inclined plane of four and a half degrees descent; or have such an elevation at the pole in its own thickness as to be equivalent to that inclination; and that would require a height of ice at the pole of two hundred and seventy-one miles, that the sheet might reach the fortieth degree of latitude. The statement of such requisition seems sufficiently condemnatory of the theory.

There are laws of limitations ever ruling all nature, including the powers of the air. These all have their boundaries they may not pass; their effects cannot transcend their limited cause. When we consider and perceive that no glacier or polar ice-sheet can be formed without snow, we must also perceive that the quantity of snow must find a limit in the heat that evaporates the water into the air that shall fall as snow. Create the Arctic climate over the world, that is requisite to maintain the supposed great ice-sheet unmelted, and you cut off the amount of evaporation necessary to form and preserve that ice-sheet. You have thereby made it an impossibility. To diminish the Sun's heat is to cut off the supply of snow to build the great glacier. Tyndall on Heat, 206. "We cannot afford to lose an iota of solar action; we need, if anything more vapour; but we need a condenser so powerful that this vapour, instead of falling in liquid showers to the earth, shall be so far reduced in temperature as to fall in snow." Ib. 207. That condenser must be *the mountains*, or be the polar cold. But the supply of *heat* from the Sun is ever a *constant quantity*. "This expenditure, (of the Sun) has been going on for ages, without our being able, in historic times, to detect the loss." Ib. 434. It is a supply ever dispensed; never spent, never varied; and will not permit the growth of the great ice-sheet. Less heat would make less snow, and snow must make the ice-sheet or glacier.

The theory supposes the ice-sheet to reach below the 40th degree of latitude; and the cold influences of that would extend over the world. There would not only be a failure of evaporation to fall as snow to maintain the ice-sheet; but the snow formed *could never reach the pole*, or approximate it, to form the head and pressure to drive southward the continental glacier. The evaporated moisture of the tropics would be precipitated in snow as soon as chilled at the freezing point first reached; that is, as soon, at least, as it reached the ice-sheet. We find such to be the law of snow precipitation on the highest mountains. "According to Tschudi the quantity of snow which falls upon that portion of the Alps which is above 10,800 feet is comparatively very small. Most of the clouds charged with snow flakes discharge their burden on the mountain slopes at elevations of 7,000 to 8,000 feet." The Earth; by Elisée Reclus, 163. Mountains in Thibet 20,000 feet in height are therefore found denuded of every particle of snow, because the dry winds there have not the moisture to dispense in snow; and for the same reason the north side of the Himalayas have the lower snow line higher than that on their south side, where the heat is greater and the moisture more abundant. Ib. 165–6. Hence also there is an *upper*, as well as a lower snow line on very high mountains. Speaking of

Mer de Glace and the Mer d'Aletsch, Reclus says, "It is a very remarkable fact, in regard to both these glaciers, and those of the Himalaya, that the ice-rivers are much longer and more abundant on the southern side of the mountain than on the colder slopes which are turned to the north. This phenomenon must evidently be attributed to the larger quantity of snow brought by the south wind, and impeded in its course by the lofty mountains." Ib. 211–2. Thus the most snow comes from the side where there is the geatest heat for evaporation.

Dr. Hector shows that the same phenomenon takes place in New Zealand as in the Himalaya and other mountains; namely that the snow fall is greatest to the windward, whenever the temperature is at freezing point: "Much of this enormous precipitation is deposited as snow in the Southern Alps, which *comb* out the moisture from the westerly winds; hence the extensive glaciers of the mountain region and the comparative dryness of the Canterbury Plains." Nature, Jan. 27, 1876, p. 259.

As the climate of the world now is, the greatest quantity of snow does not approximate the pole, though it will last longest there. It is more abundant below than above the fiftieth degree of latitude. In British America, above that degree six days of snow in a winter, and a depth of three and a half feet, are normal quantities. 9 New Am. Cy., 327. With an ice sheet down to 40 degrees of latitude the deepest snow would probably be midway between the equator and pole.

There is, therefore, no cause of the continental polar ice-sheet found in the air; nor is there any effect of it seen under the earth, where the effects should have been often seen, if it proceeded from a planetary cause, for then it should have been of periodical occurrence, and the effect have been seen in fossils in the rocks. Since land first peered above the waters to yield disintegrated material for the deposit of the sedimentary strata, the rocks have kept the registry of every species of plant and animal, and thus recorded the temperature of the globe, and told us that the time was when tropical plants grew on the shores of Greenland. There, on the east coast are the Carboniferous slates and coal, and on the west side of the Island of Disco, at latitude over 69°, are impressions of the rankly growing vegetation of the tropics. The succession of stratified rocks, as arranged by Lyell in his table in their order of deposition, number thirty-eight, 1 vol. 135, commencing at some period of that long "beginning," when the earth was first in preparation for man's inhabitancy. No stratum of all those rocks tells of an ancient glacial period, while they all proclaim that the Earth was a constantly cooling sphere, that it might become fitted for the home of human beings. This process of cooling must have followed that uniformly diminishing rate with which a hotter body radiates its heat into space, with the local exceptions made by mountain elevations, the distances of the poles from the Sun's direct rays and by ice-bearing ocean currents. And certainly the Sun has in no period of the past dispensed less heat to the Earth than now. If there be any fact on, or within the Earth, or without it, to prove the contrary of such inductions from normal causes, it

is to be shown, not conjectured, not invented. We are not to be permitted to explain a difficulty by an imagined cause that involves tenfold greater difficulties. This they seem to do who make the induction of a continental polar ice-sheet, such as the glacialists describe it, with the vividness of those who might have seen it. Though their subject be glacial they write with a fervor that betrays an enkindled imagination.

James Croll emphatically invokes an astronomical cause for the Glacial Epochs; but the astronomers have expressed adverse opinions. Humboldt. (4 Cosmos 460) thus quotes Poisson on the Stability of the Planetary system: "It follows from the theorem of Lambert, that the quantity of heat which is conveyed by the Sun to the Earth is the same during the passage from the vernal to the autumnal equinox as in returning from the latter to the former: The much longer time which the Sun takes in the first part of its course, is exactly compensated by its proportionately greater distance, and the quantities of heat which it conveys to the Earth are the same while in the one hemisphere or the other, north or south." Humboldt also quotes Arago on Excentricity: "As the excentricity always has been, and always will be, very small, the influence of the secular variations of the quantity of solar heat received by the Earth upon the mean temperature would appear also to be very limited." If these opinions be true we must look to earthly causes; and not to the Earth's orbital excentricity produced by conjunction of planets in the heavens, or variable heats from the Sun.

There is, however, one cause besides the elevation of the mountains, and the inter-continental influx of the Arctic Sea, whereby the temperature of Northwestern Europe, may at sometime, have been greatly reduced, and that without any cause at variance with the normal physical laws. We have shewn many proofs why there was a central ocean between the widely spreading systems of mountains of the Eastern and Western parts of North America. It may hence have been that the waters heaped up by the Earth's rotary motion, and the trade winds into the Gulf of Mexico, found a passage through that inter-continental sea; and were not, as now, compelled to find their exit by Cape Florida and the Atlantic Ocean, to reach and warm Western Europe. Dr. Dawson did not suggest such a cause for such effect; but said what would truly be the consequence of such cause when he said, "any change that would allow the equatorial current to pursue its course through to the Pacific, or along the great inland valley of North America, would reduce the British seas to a boreal condition." Dawson, 79. The fact shown, the induction is legitimate and inevitable; and seems to be proved by established isothermal lines, shewing how greatly the gulf-stream mitigates climate.

How then are we to account for a past period of glaciation, of whatever intensity, greater than at the present time in certain places. We may do it without invoking abnormal causes. An adequate cause exists within less than five miles of every foot of the surface of the earth. Within that limit, with land elevation to the height of the upper snow line, and breadth to hold an adequate *Mer de Glace*, yet with a sufficient declivity to put the

ice in motion by gravitation, we have all the conditions necessary to account for all the glaciation and glaciers of which we find the traces in every country. That the greater glaciers have had such cause seems apparent from their effects remaining where the glacier ice left them. Within reach is ever the producing mountain, or was the open sea to the Arctic. These are sufficing causes for all we see within the range of the causes. The grooves of greater glaciers are seen in parallel lines at great heights on the mountain sides of the glacier-valleys, where glaciers now are, and in thousands of places where they have ceased to be ; and there are the *moraines*, and the rocks *moutonné*, rounded and scored rocks in place, and those transported, all having an exact relation to the moving cause. The Earth by Reclus, Ch. 36. These are the certain proofs that the mountains have been greater, and the evaporation not less, but probably much greater, when the Earth was warmer. For these a continental or polar ice-sheet would in no wise account. It is not needed and is an unfitting explanation of the boulders spread so widely south and east of the Baltic, and even over Scotland, Wales and England ; and such degree of cold may have been so induced by mountain elevations and Arctic sea currents as to invite Arctic animals and plants southward and to drive other animals further south. "It is now beyond all question," says Reclus that the numerous lines of rocks which are found here and there all over Northern Russia have proceeded from the granite mountains of Scandinavia. When an immense sea extended over Finland between the Baltic and the Polar Ocean, the blocks of ice which fell into the water that washed the base of the Scandinavian mountains, drifted away in flotillas towards the southeast to the shores of the continent opposite. The prominent angles of the granite blocks contained in the masses of floating ice have traced out long furrows over all the points and projections of the rocks in Finland, which was then only a marine shoal. M. Nordenskiöld has ascertained that almost all these lines of erosion tend from the northwest to the southeast, and that all the rocks with which the icebergs have come into contact are polished on the side which faces toward Scandinavia, while on the other side they have in every case retained their uneven surfaces, their projections and their clefts. With regard to the boulders themselves, they are all more rounded by friction the more distant they are from the Sweedish mountains of which they once formed a part." Ib. 219. And the same effects are there yet taking place, on a smaller scale.

During the winter of 1862–3, immense masses of ice, coming from Finland, were cast upon the southern coast of the gulf, and thrown upon the land a distance of more than three hundred yards from the shore, and to a height of thirty feet above the level of the sea. The ice which was forty to fifty feet deep, overwhelmed many dwellings and whole forests. In the latter large quantities of stones were subsequently found, which the ice left when it thawed. Reclus, 219, citing Keyserling and Von Baer.

The Danish Professor, Dr. Forchhammer, relates a striking fact to show that large quantities of rocky fragments are annually carried by ice out of

the Baltic. In the year 1807 he says, at the time of the bombardment of the British fleet, an English sloop of war, riding at anchor in the roads, at Copenhagen, blew up. In 1844, a trustworthy diver found the space between decks entire, but covered with blocks from six to eight cubic feet in size, some heaped on others; and he found all the sunk ships he visited thus loaded with rocks. 1 Lyell, 382. Now when the Baltic sea was opened to the north pole, and when much of Europe south of the Baltic was below the water level, there was the same condition there as has been shown to have been in North America; namely, an open sea to bear down ice-rafts from the north to supply the drift and boulders that are found spread over both countries, bringing with them a cold atmosphere.

The most recent account of the drift on the eastern side of North Wales, by D. C. Davies, F. G. S., gives us his conclusions: "1. The majority of the deposits are of local origin, being derived from the mountainous regions of North Wales, then an Archipelago of islands. 2. But from the plentiful admixture of foreign matter, he infers *an open sea* on the north. 3. He insists upon the necessity of *aqueous conditions*; the coast would be partly ice-bound, but *there was no general ice-cap*. Besides the general alterations of level there were *local alterations of level*. Proofs of this were to be seen in the neighborhood of Oswestry, beyond which town the Scotch granites do not seem to pass. This the author considered due *to currents* deflecting the *ice-rafts*, &c. Nature, Feb. 17, 1876, p. 318.

Let us be reassured, then, of the safety of Europe and North America, and the world. The Creator, we may believe, did not create the best parts of this Earth and plant there the highest civilizations ever seen upon it, with purpose of its utter destruction. These countries in Europe and America are the hopes of the race, with means of execution, now presented, as they have never been before. There is a uniformity of law, and stability in Nature, that justify man's confidence in the ruling of The Supreme Power, and that He is good. They who most profoundly study His works are the most thoroughly convinced that there is no eccentricity or caprice in His Rule; that He is "The same yesterday, and to-day, and forever." The oscillations of the Earth have become almost infinitessimal; the vertical vibrations as measured by the temple of Jupiter Serapis have not exceeded thirty feet; many volcanoes have been sealed up and people live securely within the rim of former craters; the Valley of the Mississippi will never again be an ocean's bed; the Gulf Stream will continue to mitigage the climate of Europe and preserve its genial temperature; and the Earth continue to turn upon its axis, and to revolve in its orbit, without a tremor; without a moment's loss or gain. God's balance wheel belts this Earth; and He gave to our globe those impulsions in its rotation and orbit which will forever precisely counteract its weight, and maintain its motions with such exactness as will keep all true time forever. Such momentum was given once forever. If not so, then God is forever sustaining His creation.

This earth has never, and upon the certain evidence of Geology, will never suffer a cataclysm. The faults of strata are limited and local; the

surface is fashioned by exterior agencies that level, smooth and beautify the world, and fit it for man's use and enjoyment, but which can never mar the sublimity of the cataract, or the majesty of the mountains; many of these crowned with never wasted snows. Some volcanoes yet burn to relieve the earth of the throes of its internal heat and gases, and to tame the earthquakes; yet are the latter sufficing agencies needed to raise the mountains commensurately with the degradations of the disintegrations and erosions of prevailing frosts, heats and rains. None of these, however disturb the general movements of the earth in its orbit, or on its axis, by the slightest vibration, or cause the delay of a second in time in its annual revolution. The Supreme Ruler has taken into the account every cause, and provided against disturbance, in advance; or at every moment keeps all things adjusted to absolute truthfulness. The cooling and shrinkage of the earth's crust, would upon mechanical principle, shorten the radius of the earth's axis, and hasten its rotation, and shorten the day; but as Humbolt says, this is provided against by the celestial movements being adapted to the thermal condition of our planet; and "from the comparison of the secular inequalities of the Moon with the eclipses observed in ancient times, it follows that since the time of Hipparchus, that is, for two thousand years, the length of the day has certainly not diminished by the hundredth part of a second. The decrease of the mean heat of the globe during a period of two thousand years, has not, therefore, taking the extremest limits, diminished as much as $\frac{1}{360}$ of a degree of Fahrenheit." 4 Humboldt's Cosmos, 168.

Some scientific men, and some that may not be truly such, seem fond of writing sensationally, to disparage the creation and to alarm mankind as to the stability and permanence of our planetary home. Andrew Wilson, in giving his travels in "The Abode of Snow," or Himalaya, in the first page of his preface suggests that it is not "an improbable theory that when the accumulation of ice round the south pole has reached a certain point, the balance of the earth must be suddenly destroyed, and this orb shall almost instantaneously turn transversely to its axis, moving the great oceans, and so producing one of those *cyclical catastrophies*, which there is *some reason to believe* have before now interfered with the development and civilization of the human race." One supposes, of course, the traveler to be playfully jocose when he thus speaks to recommend his favorite Himalaya as a safe place of retreat; the Himmels or heavens of our Aryan ancestors; yet Professor Winchell in a work of science is even more sensational, and has several serious chapters upon the inevitable progress of Creation to its ruin; in chapters headed "The Reign of Universal Winter," "The Sun Cooling off," "The Machinery of the Heavens Running Down;" and quotes Helmholtz as saying, "The inexorable laws of mechanics shew that the store of heat in the sun must be finally exhausted." And thus the author of the article "Force," in Chamber's Encyclopedia, gives his views of the finality: "This, then, it appears, is to be the last scene of the great mystery of the universe, chaos and darkness, as 'in the beginning.'"

Either then, the universe has been subjected to laws to make waste and decay impossible, and all things that undergo change are preserved in quantity and energy to preserve the whole forever in balance; or there is a Power that ever renews them; for we see that creation does not wax old, but that equal quantities of matter and force remain ever operative without detection of a moment's pause through thousands of years; without the loss of an atom of matter, of force, of heat, or light, without a discord, or tremor in the harmony of the Universe.

Adhering strictly to the Baconian canon of philosophy, to which all philosophers must be held; that is, to proceed only on well ascertained facts, and thence making inductions only in accordance with the laws of nature, also ascertained as facts, it is submitted that it will not be found that creation is ever growing weaker, is not verging to decay and annihilation. The more we shall know, the more profoundly we shall consider, the more surely shall we be reassured that this earth is not to perish by ice, or water, or fire; that the force that holds the systems of suns and planets in their rotary movements will never abate; that suns will not burn to cinders, nor their heat and light be spent or extinguished. And by the observance of the same canon of philosophy, of certain ascertainment of facts and strictness of induction, we must also infer from all creation, and creation's laws, that it had an Author to give it law, who wills to conserve it for ever; Him of whom we truthfully say, "Thy law is the Truth:" By, "Thy faithfulness shalt Thou establish the very heavens."

Stated Meeting, June 16, 1876.

Present, 7 members.

Vice-President, Mr. Fraley, in the Chair.

Letters accepting membership were received from Dr. A. E. Nordenskiold, dated Philadelphia, June 13, 1876, Dr. Juhlin Dannfelt, dated Philadelphia, May 31, 1876, Mr. I. Lothian Bell, dated Philadelphia, June 7, 1876, and Mr. P. Cunliffe Owen, dated 2 Residences, South Kensington Museum, London, May 20, 1876.

A photograph of Dr. I. Lea, of Philadelphia, was received for insertion in the Album.

Receipts for No. 92 Proceedings were received from M. M. Rokitansky & Hyrtl, of Vienna.

A letter of envoy was received from the Royal Bavarian Library, dated March 18, 1876.

Notice of change of residence from St. Petersburg to Jena of M. Böhtlinek was received from Watkins & Co. per Smithsonian Institution.

Donations for the Library were announced from the Academies at Berlin, Munich, Boston, Philadelphia, and San Francisco; the Societies at Leipzig, Ulm, Salem and Boston; the Observatory at Munich; the Library at Munich; the Editors of the Revue Politique, and Nature; the London Geographical, Astronomical, and Zoological Societies; Mr. Edmund Quincy, Prof. O. C. Marsh, Dr. Isaac Lea; Silliman's Journal, American Chemist, Journal of Pharmacy, Penn Monthly, and the Massachusetts State Board of Health.

The Committee on Dr. Valentino's Memoir reported progress, and was continued.

The death of Dr. Geo. Allen was announced by the Secretary, and on motion Prof. Thompson, of the University of Pennsylvania, was appointed to prepare an obituary notice of the deceased.

Mr. Price communicated the following circular, read and

unanimously adopted at a meeting of the Commissioners of Fairmount Park, held June 5, 1876:

TREES FOR THE FAIRMOUNT PARK.

This Park is in the earliest stage of its formation. A principal feature of its beauty must consist of trees, planted in manner to form pleasing landscapes, and in trees planted singly, in groups, and groves. The Commissioners desire also to add a botanical interest to the Park, by having in it every tree that will stand our climate. To promote this object and duly to honor the name of Michaux, father and son, the American Philosophical Society have devoted half the income of the legacy left by the son to the Society, of about three hundred dollars ($300) per annum. This has been applied to the planting of the Michaux Grove of oaks, and to importing and planting in our nurseries many varieties of oaks, &c. The announcement is now made, during the holding of the Centennial International Exhibition as an auspicious occasion to invite contributions of trees, acorns and seeds, from all parts of the world, and from all persons who love the beautiful in landscape and to promote botanical science.

Communications may be made to Eli K. Price, No. 709 Walnut Street, Philadelphia, Chairman of Committee on Trees and Nurseries in the Park Commission, and Chairman of the Committee on Michaux Fund in the American Philosophical Society.

Mr. Price exhibited specimen twigs, bearing leaves, broken from every variety of oak imported and growing in the Michaux Grove. Respecting this grove he desired to have this minute placed on the Journal of the Society.

The Chairman of the Committee on the Michaux Grove reports, that he has visited to day the Fairmount Park Nursery, and found the grounds well taken care of, and the large stock of trees in a flourishing condition. Of the acorns planted before last winter nearly all have grown except those of the "Bartram Oak;" and of the fifty or sixty of these planted, not one has grown. So far the proof is in favor of that oak being a hybrid.

Mr. Davenport being invited to speak of the Eucalyptus trees of Australia, and the probability of growing certain species of Eucalyptus in our latitude, remarked that his botanical information was drawn chiefly from the pretty thorough reconnoisance of that continent by Dr. Schomberg, Director of the Botanical Gardens at Adelaide, and Baron

von Müller, Director of the Gardens at Melbourne, who recognized about one hundred and fifty species or varieties of Eucalyptus, many of large size, some growing grandly on arid plains, others on Australian "Alps" and "Pyranees" at various elevations; the highest mountain summits being not above 7000 feet over sea level. Some of these mountain kinds will probably grow in Philadelphia, and he will be happy to assist their introduction. He had seen large plantations of Eucalyptus between St. Jose and San Francisco, and others growing in the interior. He had come to the conclusion in his own mind many years ago that the fragrance diffused through the Australian atmosphere by the essential oils of these trees must account in part for the remarkable immunity which settlers and travelers, however exposed at night in the bush, had always enjoyed against malarious fevers, although the climate was as hot as in malarious districts of Italy. No malaria was known, although low typhoid fevers were not unknown.

Mr. Davenport remarked the great difference between the vegetation of Adelaide and Philadelphia, and had been much impressed by the exuberant foliage of the Park around the Centennial grounds.

Prof. Houston reported the result of his proposed experiment with the 19″ Fresnel lens through which, about two weeks ago, he had concentrated the beams of a full moon in a spot of about a quarter of an inch diameter, on the flags of a Crooke's radiometer, without obtaining the least movement; whereas the same instrument, at the same time, was moved by the heat of boiling water in a glass tube, but was not sensitive to radiant heat below about 212°. In a room, however, the heat of the hand would move it, a lighted match would make it move swiftly, even the dull red glow of the extinguished end of a match gave a sensible motion.

Pending nominations 793 and 803 were read.

And the meeting was adjourned.

Stated Meeting, July 21, 1876.

Present, 6 members.

Dr. LeConte in the Chair.

The reading of the minutes was dispensed with.

Letters of acknowledgment were received from Mr. C. E. Dutton, dated Omaha (97), and Mr. A. H. Worthen, Warsaw, Ill. (97).

A letter of envoy was received from the Smithsonian Institution, dated Washington, July 20.

A letter was received from Prof. Charles E. Anthon, dated College of the City of New York, June 29, 1876, with the coin and description referred to in his letter of February 11th, read at the meeting of February 18, 1876.

A letter was received from Mr. Charles A. Kesselmeyer, dated 1 Peter Street, Manchester, England, 21st June, 1876, presenting to the Society a copy of his "Calendarium Perpetuum Mobile," and enclosing a photograph with an explanation of the same.

Donations for the Library were received from the Berlin Physical Society; German Geological Society; Royal Prussian Academy; Dr. L. Wedekunde; Bamburg, Freiburg, and Chemnitz Natural History Societies; F. Kramer; Ulm Antiquarian Society; Royal Academy of Belgium; Royal Academy, Amsterdam; Netherland Botanical Society at Nimegen; Paris Geographical Society; Bureau des Longitude; Annales des Mines; Academy of Medicine; Editors of Nouvelles Météorologiques and Revue Politique, Paris; Col. E. Belleville; Turin University Observatory; G. Mazzola; Prof. A. Dorna; Society of Arts, Victoria Institute, Royal Asiatic, and Astronomical Societies, and Nature, London; Royal Society, Tasmania; Academy of Arts and Sciences, Connecticut; Silliman & Dana; Yale College; Mr. Osman Fisher; Essex Institute, Salem; Peabody Institute; Editors of American Chemist; Dr. C. H. Berendt; Pharma-

ceutical Association; Editors of the Penn Monthly; Franklin Institute; Editors of the Medical News and Journal; Mr. Robert Briggs, C.E.; Baltimore Peabody Institute; United States National Museum; Geological Survey of the Territories; G. B. Goode; Dr. Newberry; East Tennessee University; Academy of Science, St. Louis; G. A. Engelmann; and Hudson Hall, Savannah.

A donation for the Cabinet was received from Prof. Charles E. Anthon, of a coin of 1670, the date of the settlement of Quebec, struck by order of Louis XIV., the first currency of French North America.

The death of Prof. J. J. Kaup, of Darmstadt, was announced by letter of Prof. Joseph Henry, dated July 20, 1876.

A communication received from Prof. Charles E. Anthon was entitled, "On a Silver Louis of Fifteen Sous, struck under Louis XIV. for circulation."

Prof. Chase communicated a note on suggestions of Cosmical and Kinetic Harmony by Profs. Alexander, Pierce, Lovering, and others, and on some of the mathematical principles involved.

Pending nominations 793 and 803 were read and balloted for.

The letters of Prof. Henry and Charles A. Kesselmeyer were referred to the Secretaries with power to act.

On scrutiny of the ballot boxes, the following persons were declared by the presiding officer duly elected members of the Society, viz:

Prof. Richard Ackerman of Sweden.

Prof. John Johnson of Middletown, Conn.

And the meeting was adjourned.

Stated Meeting, August 18, 1876.

Present, 6 members.

Vice-President, Mr. Fraley, in the Chair.

The minutes of the last meeting were read.

Letters of envoy were received from the Smithsonian Institution, U. S. Coast Survey Office, London Meteorological Office, Boston Society of Natural History, and Gen. Henry L. Abbot.

Letters of acknowledgment were received from the Boston Society of Natural History, July 28th, (XV, ii.; 94, 97); Royal Astronomical Society, London, July 11th (XV, ii.; 62, 88); East Tennessee University, Knoxville, July 22d (97); and various libraries and members receiving Proceedings No. 97.

A letter was received from Prof. G. A. Matile requesting the loan of archæological specimens from the Cabinet to make casts from them for the Princeton Museum.

Photographs of Prof. Thomas C. Archer and Dr. H. R. Göppert were received for the Album.

Donations for the Library were received from the Academies at Berlin and Bruselles; the Congress of Naturalists at Berlin; the Societies at Marburg, Görlitz, Bremen, and Bordeaux; Zoological Garden at Frankfort; Geographical Society, Editors of the Revue Politique, and M. P. Frémeaux, at Paris; Royal Astronomical Society, Mr. T. H. Tizard, Mr. J. M. Stuart, and Editors of Nature, London; Geological Survey of Canada; Silliman & Dana, New Haven; Editors of the Penn Monthly, Medical News, and American Journal of Pharmacy, Philadelphia; Gen. H. L. Abbot; U. S. Coast Survey; Dr. Newberry, and the Rio Janeiro Museum.

Mr. Chase remarked upon the closeness of agreement between the estimates of solar radiating force derived from Crook's Radiometer and from the Nebular Hypothesis.

Dr. Cresson described successful experiments with Wootten's method of utilizing coal dust in locomotives and ocean steamers, and in puddling iron; exhibiting samples of the iron refined in the process.

New nomination 804 was read.

Mr. Fraley reported as received and paid to the Treasurer the interest on the Michaux Legacy, due July 1, 1876.

On motion of Mr. Chase, seconded by Dr. LeConte, the Curators were authorized to furnish Profs. Guyot and Matile such antiquities as they may wish to copy, taking the usual guarantees for their safe return.

Applications of Messrs. Trübner & Co., and others, for copies of Transactions and Proceedings, were referred to the Librarian with power to act.

And the meeting was adjourned.

Stated Meeting, September 15, 1876.

Present, 15 members.

Vice-President, Mr. Fraley, in the Chair.

Letters of acknowledgment were received from the Leipzig Astronomical Society, dated May, (xiv., 93, 94, 95); the Teyler Foundation, Harlem (94); the Royal Society of Science, Göttingen, April (XV, 94); the Central Institute of Meteorology at Vienna, June (93, 94); the Royal Academy, Amsterdam, March 12 (XV, i. ii., 94 and XV, 93); the U. S. Naval Observatory, Washington, June 30, (97); and the Zoologico-Botanical Society, Vienna, May (92).

Letters of envoy were received from the Royal Observatory, Turin, dated July 18; Royal Academy, Amsterdam, December 15, 1874; Mr. Geo. Engelmann, St. Louis, July 6; the Department of the Interior, and the Department of State, Washington, June 29th and August 17, 1876.

Donations for the Library were received from the Academies at Copenhagen, Brussels, Rome, and Philadelphia; the Geological, Zoological, and Anthropological Societies at Vienna; the Art Union at Ulm; the Geographical Society, Editors of Nouvelles Météorologiques and Revue Politique, at Paris; the Antiquarian Society, Dr. Joseph Prestwick, and the Editors of Nature, in London; the Melbourne Mining Survey; Maine Historical Society; Essex Institute; Dr. H. Carrington; Boston Society of Natural History; Hon. R. C. Winthrop; Dr. S. A. Green; Silliman & Dana, New Haven; Editors of the American Chemist; Prof. G. A. Matile, Franklin Institute, College of Surgeons, and Editors of the Penn Monthly, Medical News, and Journal of Pharmacy, in Philadelphia; U. S. Departments of War and State, Surgeon General, and Signal Service Bureau, Washington; Editor of the Scientific Monthly at Toledo; U. Stempel at Chicago; and Dr. Jarvis of Dorchester, Massachusetts.

A photograph of Dr. T. S. Hunt was presented for insertion in the Album.

A letter from Prof. J. Henry, requesting attention to a letter from the Holland Society of Science, was referred to the Librarian with power to supply deficiencies in the series of A. P. S. Publications in the Library of that Society.

A letter from the Freiburg Natural History Society was referred to the Librarian with power to supply Proc. 89.

A letter respecting deficiencies was received from the Society at Würtemburg and referred to the Librarian.

A letter from D. S. Sheldon, Librarian of Griswold College, Davenport, Iowa, asking for Dr. Hor. Wood's memoir on Myriapoda was referred to Dr. Wood.

A circular was received from the Société des Voyages at Paris.

Mr. Lesley exhibited a neatly executed colored geological lithograph map of Mr. B. S. Lyman's Official Survey of the Island of Yesso, as the first work of the kind done in Japan.

Dr. Hunt, on invitation, described the history of geological opinion respecting the gneisses, green rocks and other metamorphic strata of the Alps, with the recent accordance of the views of Gastaldi and Favre, as opposed to those of Lory and others, with previously published views of his own, after he had recognized the Laurentian, Huronian and Montalban systems in the massif of Mont Blanc.

Pending nominations Nos. 804, 805, 806, and 807 were read.

On motion the use of the Hall was granted to the Commissioners of the Geological Survey for their meeting on the 19th inst.

On motion of Mr. Pearse it was resolved, That the Board of Commissioners be requested to recommend to the Governor of Pennsylvania the propriety of taking such measures as may be necessary for preserving the collections of the Geological Survey in the same place in which the collections presented by the Commissioners of foreign governments may be arranged.

And the meeting was adjourned.

Stated Meeting, October 7th, 1876.

Present, 10 members.

Secretary, Dr. Le Conte, in the Chair.

Dr. Moor, a newly elected member, was introduced to the presiding officer and took his seat.

A letter of acknowledgment was received from the Observatory at Prague, dated Sept. 4 (XV, ii, 93, 94), from the R. Geological Society of Ireland, Sept. 16th (XIV Proc.), and from various correspondents by postal cards (97).

Letters of envoy were received from the Society at Marburg, April 1876;—the French Ministry of Public Works, Sept. 1876, desiring a return donation of some books on civil engineering or technology for the library of the Ecole des Ponts

et Chaussées in Paris; from the Linnean Society, dated London, Aug. 18th; from the Meteorological Office, dated London, Aug. 1876; from the Secretary of the State of Illinois; and from the Davenport (Iowa) Academy of Natural Sciences, Sept. 15th, desiring complete sets of Transactions and Proceedings.

A letter was received from Mr. C. A. Kesselmeyer, 1 Peter Street, Manchester, England, presenting a copy of his Card Calendarium.

Donations for the Library were received from the R. Belgian Academy; French Ministry of Public Works; Annales des Mines; Nature; Linnean Society; Society of Antiquaries; R. Geological Society of Ireland; Silliman and Dana; Editors of the American Library Journal and Medical News; Buffalo Society of Natural Sciences; and the Davenport Academy of Natural Sciences.

Professor Houston made an exhibition of a new telegraphic machine called a "Pneumo-dynamic Relay Sounder," where the local battery is replaced by compressed fluid, and explained it by a working model and diagram. Attached to the armature is a bent lever, with a valve mechanism opening and closing a conduit leading from a reservoir of condensed air. The issuing air swells out a diaphragm of rubber cloth covering a space of one sixty-fourth of an inch, and moves a disc, which moves the striking lever, the return stroke being effected by a spring. The balance of the valve is so adjusted as to diminish for opening the valve. This is affected by an accessory diaphragm pressing upon the other arm of the bent lever; the tension is then equal to the adjusted difference. The instrument works with rapidity enough to get responses easily to thirty-six beats per second.

Pending nominations Nos. 804, 805, 806, 807, and new nomination No. 808, were read.

On motion of Mr. Gabb, the committee on Dr. Valentino's paper was requested to report at the next meeting.

And the meeting was adjourned.

Stated Meeting, October 20th, 1876.

Present, 20 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the J. V. N. in Würtemberg, dated Stuttgard, June 24th (complete set of T. & P); the Swiss Society at Berne (92–96), and Professor C. E. Anthon, dated New York, Oct. 19.

Letters of envoy were received from the Swedish Academy, Stockholm, July, 1876; Royal Saxon Society, Leipzig, June 1; Swiss Society, Berne; and Royal Belgian Academy, Bruxelles.

Donations for the Library were received from the Academies at St. Petersburg, Stockholm, Copenhagen, and Bruxelles; the Observatories at St. Petersburg, and Prague; the Geological, Geographical, Zoölogical, and Meteorological Institutions at Vienna; the German Geological Society, Berlin; the Saxon Society at Leipzig; the Societies at Stuttgard, Ulm, Bern, and Lyons; M. de Koninck at Brusselles; the Geographical and Antiquarian Societies at Paris; the Geographical Society, the Victoria Institute and Nature, London; the Glasgow Philosophical Society; Melbourne Inspector of Mines; Canadian Journal; Essex Institute; Boston Nat. Hist. Society, and Massachusetts Commission to the Centennial; Cambridge Museum; American Antiquarian Society; Franklin Institute; Penn Monthly; Journal of Pharmacy, American Journal of the Medical Sciences; and Engineer Department of the United States Army.

Donations for the Cabinet were reported from Professor Guyot, of copies of original antiquities in the Museum of Princeton College, made by Professor Matile, who, with these copies, returned to the Cabinet the originals loaned to him from the Poinsett collection, having made copies of them for the Princeton Museum. Other originals were then selected to be copied and returned in due order.

The Secretary, in exhibiting these donations, said that they

were copies of prehistoric remains: snakes, tortoises, and other bizarre figures, found in Porto Rico.

He had suggested to Professor Matile that certain duplicates in the Poinsett collection might be exchanged for duplicates in the Princeton collection. Mr. Matile and Mr. Guyot subsequently requested that the Society would consider a request for such exchanges; Mr. Matile selected duplicates; and the Secretary displayed specimens of the selection to show in what form the exchanges might be effected.

The death of Sir William Jardine, and Dr. John Hughes Bennett, of Edinburgh, members of this Society, was put on record, the Smithsonian Institution having returned copies of the Proceedings so marked.

The Committee on Dr. Valentino's Memoir reported that they considered it advisable to return it to the author for certain emendations, which, on motion, was so ordered.

Dr. Genth reported his discovery of a new mineral, the telluride of mercury, in the Keystone Lode, Magnolia District, Colorado. Further investigations are in progress and will be reported. The ore contains no silver. Native mercury is said to have been noticed in the mine. *

Pending nominations 804, 805, 806, 807, 808, and new nominations 809, 810, 811, 812, were read.

Ballots were then cast for Nos. 804 to 808.

The subject of providing additional conveniences for the members in the rooms of the Society was referred to the Hall Committee with power to act.

The formal application of Mr. Wooten for the premium of $500 for inventing a successful method of using anthracite slack was referred to the Officers and Council.

On motion, the subject of exchanges of duplicates with the Princeton Museum was referred to the Curators, with instructions to report their action at the next meeting.

Mr. Lesley communicated the fact of experiments being made at Johnstown, by order of the Geological Commission, to obtain some reliable facts about the conduct of mixed an-

* Dr. Genth has named the new species *Coloradoite*.

thracite and bituminous slacks, with and without pitch, in the coke oven.

Mr. Briggs urged the need of circumspection in offering and decreeing premiums to inventors before continuous and complete success; and instanced the use of all the anthracite slack in the manufacturing establishments of New England for the last twenty years, by a variety of methods, all of them successful. In respect of the mixed anthracite and bituminous slacks his experience had been that their combined clinkers were so much worse than the clinkers from either one separately that the mixture could not be used in the fire box.

The meeting was adjourned after scrutiny of the ballot boxes by the presiding officer, who declared the following persons duly elected members:

Mr. Samuel Davenport, of Adelaide, Australia.
Dom Pedro d'Alcantara, Emperor of Brazil.
John F. Hartranft, Governor of Pennsylvania.
Mr. W. Milnor Roberts, of New York.
Mr. Aug. R. Grote, Director Mus. Buffalo S. N. H.

Stated Meeting, November 3rd, 1876.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Samuel Davenport, dated Main Cent. Building, Phila., Oct. 26; Mr. A. R. Grote, dated Buffalo, New York, Oct. 26; Mr. John Johnston, dated 812 Broadway, N. Y., Oct. 31, 1876.

A letter from Professor Jos. Henry, dated Smith. Inst. Washington, D. C., Oct. 27, requested a set of Transactions for the Wellington Museum, in New Zealand, under the charge of Dr. Hector, Director of the Geological Survey. On motion the request was granted.

Donations for the Library were received from Mr. Levi Capron (Kaiticushi, Tokio, Japan); the Academies of Ber-

lin and Brussels; the Societies at Ulm and Bath; the Geographical Society and Meteorological Office; and Nature; the Mass. Hist. Soc.; Silliman's Journal; Penna. Historical Society; Penn Monthly; Librarian of Congress; Kentucky Geological Survey; Mexican Geographical Society; Professor R. S. McCulloch and Mr. Samuel Davenport, of New Holland.

A circular letter from Dr. Aug. Le Jolis, dated Cherbourg, Oct. 12, respecting the 25th Anniversary (Dec. 30), of the Society of Science, was on motion referred to the Secretaries to be suitably answered, after being signed by the President.

A communication, entitled "On the Atmosphere of the Sun and Planets, by David Trowbridge, A.M.," (Professor at Waterburgh, Tompkins Co., N. Y.) was received from Professor Kirkwood, of Bloomington, Ind.

Professor Chase made a verbal communication of his views respecting intramercurial bodies revolving around the Sun.

Mr. Briggs described the difficulties in the way of a successful discussion of the type form of the *vena contracta* in hydraulics.

Professor Houston continued the topic, and added remarks upon the nature of the form and movements of the "ventral segments," especially in cases where musical vibrations were employed to effect them.

Pending nominations Nos. 809, 810, 811, 812, were read.

The curators reported, recommending the proposed exchange of duplicates with the Princeton Museum. The report was accepted and adopted.

And the meeting was adjourned.

Stated Meeting, November 17*th*, 1876.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Mr. W. Milnor Roberts, a newly elected member, was introduced to the presiding officer and took his seat.

A letter accepting membership was received from Mr. W. M. Roberts, dated, Bristol, Pa., Nov. 5, 1876.

Letters of acknowledgment were received from the Foundation Teylor, Harlem (95, 97), and the Danish Academy at Copenhagen, Oct. 17 (95).

A letter of envoy was received from the Board of Commissioners of the Second Geological Survey of Pennsylvania, Harrisburg, Nov. 16, 1876.

Donations for the Library were received from the Editors of the Mining Survey of Melbourne; the Academies at Vienna and Copenhagen; the Society at Lausanne; the Revue Politique and London Nature; Mr. Scudder, of Boston; Mr. Packard, of Cambridge; Yale College; Professor E. D. Cope; Editors of the American Chemist; Medical News and Journal of Pharmacy; Franklin Institute; the Geological Survey of Pennsylvania; and the Department of the Interior.

On motion, the bill of Mr. Hall for repairs of the roof was ordered to be paid.

On motion, the Librarian was authorized to exchange the Proceedings for Poggendorff's Beiblätter.

The death of Judge Walter A. Lowrie, at Meadville, Nov. 14th, aged 69, was announced by Mr. E. K. Price.

A communication, entitled "Remarks on the Tonkawa Language" by Mr. Albert S. Gatschet, was presented by Dr. Brinton, with a personal notice of the author, well-known for his work on the geographical nomenclature of Switzerland. He was connected with Von Ruprecht and others on the Wheeler Expedition, and has a book in the Weimar press describing twelve Indian languages of the Southwest. The materials from which he has made the well-written and valuable communication to this Society are all original or unpublished.

Dr. Cresson exhibited a bottle of nauseous smelling well water from near Trenton, N. J., which his analysis showed to contain no animal organic impurities, although a cesspool stood at the distance of two hundred feet; but about one

hundred pounds of vegetable organic impurities (in the million gallons) derived no doubt from a marsh situated higher up the slope of the hill, and about a quarter of a mile off, or from truck farms in the same direction a half mile distant. The drainage seems to break down, through the loam and clay cover, into the rock, and find its way by the bed-plates or cleavage-planes to the well.

Professor Frazer adduced an instance where the water of a well at least forty feet above the level of the Jenny Jump Mountain Great Marsh, in Northern New Jersey, was made poisonous in hot dry seasons especially, by the upward percolation of marsh water.

Dr. Cresson said that in the dryest times the subsoil on the heights of Broad Mountain in Schuylkill Co. Pa. was always kept damp by upward percolation.

Professor Frazer described his observations at a recent visit to the Bamfordville Zinc Works in Lancaster Co. Pa. a mile east of Landisville, superintended by Mr. Spilsbury. The deposit is of great interest to the geologist as well as profit to the owners. Instead of being a carbonate, or silicate, or mixture of these two species of zinc ore, as at Saucon near Bethlehem, and in the Western States, it is a sulphide, a very light yellowish brown zincblende, sometimes quite colorless.

He described the process of treating the ore by crushing; bolting into four or five grades of fineness; jigging, or as to the finest grade buddling; and immediately roasting while wet, fresh from the jig. By using the *wet* material Mr. Spilsbury claims that he desulphurizes more readily. The roasted ore is then retorted with fine anthracite dust, and to the mixture Mr. Spilsbury adds 1 to 1. 5 per cent of salt, claiming to get thereby 5 to 6 per cent more zinc from the ore than he could without the use of the chloride. Professor Frazer was desirous of obtaining the opinions of experts on the two points thus observed.

[*Continued on page* 333.]

Silver Louis of Fifteen Sous, struck under Louis XIV., for Circulation in French America.

By Charles E. Anthon, LL.D.,

PROFESSOR OF HISTORY AND BELLES-LETTRES IN THE COLLEGE OF THE CITY OF NEW YORK.

(*Read before the American Philosophical Society, July 21st,* 1876.)

Description—Silver. LVD · XIIII · D · G · [Mint-mark, Sun in splendor, the badge of Louis XIV.] FR · ET · NAV · REX · (Louis the 14th, by the grace of God, King of France and Navarre.) Bust of Louis XIV., laureate, to the right, in corselet and mantle; margin serrated. *Rev.* GLORIAM · REGNI · | TVI · DICENT · ("They shall speak of the

glory of thy kingdom,") 1670. On a crowned shield, three *fleurs-de-lis* (two and one). Above the crown, a crowned A; beneath the shield, between the dot after REGNI and the dot before TVI, A (for Paris, the place of striking); margin serrated. Size 13, scale of the Philadelphia Numismatic Society, *i. e.*, thirteen-sixteenths of an inch. Condition, barely circulated.

Although there has existed among us, for the last quarter of a century, a very considerable degree of interest in the subject of our pre-revolutionary coinage, and although the taste for collecting and studying such specimens of it as can be procured has steadily increased, till the majority of the rarer and more remarkable pieces extant have found their way into the cabinets of collectors, to the great enhancement of the price of those which remain in the market, and with a corresponding whetting of the appetite to possess them on the part of antiquarians, it strangely happens that the beautiful coin represented above, demonstrably American, and suggestive of important historical remembrances as it is, has remained neglected and unsought for. No author on American Numismatics seems to have been aware of its existence until the present writer, in Vol. IV., No. 9, for January, 1870, of the American Journal of Numismatics, which he then edited, called the attention of its readers to the fact. A brief and unsatisfactory notice of it, not founded, as is confessed, on actual inspection, forthwith appeared in Sandham's "Supplement to Coins," &c., of Canada, Montreal, 1872; the main work, published in 1869, being silent on the matter. But Mr. Sylvester S. Crosby, of Boston, who has lately (1873–1875) produced the last and best work on the general subject, entitled, "The Early

Coins of America, and the Laws governing their Issue," and proves himself, on every page of it, to be a diligent and conscientious laborer, thinks himself called on to adopt an apologetic tone when mentioning this piece, and to speak of it as "not strictly included in our original plan." Yet his purpose, or "original plan" was, in his own language, "to give all the trustworthy information at" his "command, relative to such coins, or tokens, which were intended to serve as coins, that were either struck in those parts of America which now constitute the United States, or were intended for use therein;" and it cannot be controverted that this is the earliest official coin of a region embracing at least half of the States which now constitute the Union. We are not perhaps, in general, sufficiently alive to the truth that, from the Atlantic to the remote West, the beginnings of colonization were chiefly made by France. Not Canada and Louisiana, merely, formed the French America of a once far from improbable future. In an authority easy to consult, Bancroft's History of the United States, Vol. II., we find a "Map of French, English, Dutch, Swedish and Spanish possessions, or claims in the United States, in 1655." A narrow strip from the Kennebec to Cape Fear, is all that is marked as not French, to the northward of Florida. A large part of Maine, all West Virginia, South Carolina, Georgia, the greater part of New York and of Pennsylvania, and from these all westward, as far as exploration had then extended, are French. Every one of the States comprehended within the area thus roughly denoted, may regard the coin in question as its earliest monetary relic.

Without, however, going back to years anterior to its date, or looking away from the broad double valley, which extends between the Alleghanies and the Rocky Mountains, or including States of which any portion lies outside of these limits, we can easily, we think, form a list of fifteen, in each of which the collector, present and to come, must regard this "Gloriam Regni" of 1670, as its most ancient numismatic monument. The reader of history is aware that "Louisiana" was, in 1712, defined by authority as comprising all the country drained by waters emptying directly or indirectly into the Mississippi; while the schoolboy has been taught that, out of the "Louisiana purchase" of 1803, alone, have already been formed fifteen States and territories, eight of the former and seven of the latter. Since it happens that, in the article already referred to (American Journal of Numismatics, Vol. IV., No. 9, for January, 1870), the present writer, just two centuries after the first appearance of this coin, introduced it to American collectors as a new "Colonial," not known to them before, and proper to take the place usurped by one familiar to the numismatic fraternity under the name "Louisiana copper," or "R F," he must now again insist on the correctness of this view, and re-affirm that the GLORIAM REGNI is the earliest colonial coin of at least half the States of the Union. Of course we do not mean that it actually circulated in the whole vast region mentioned; but it may have appeared accidentally in any part thereof, and, wherever it did so appear, it was, in the

estimation of any Frenchman who might behold it, the coin of the realm which he trod.

It is, then, our oldest French "Colonial." Mr. Crosby may boldly represent it as such in his next edition. No apology will be required. Both he, indeed, and his predecessors, needed rather to defend (as he attempts to do), or, in fact, avoid altogether, the introduction of the "Sommer Islands," (or Bermuda) patterns for shilling and sixpence, in a work on the coinage of the United States, where they can have no just claim to stand.

With a few brilliant exceptions, our prominent numismatic collectors, and even authors, have not been men of much research or of a wide range of reading. They have delved with greater or less industry in a narrow field; and authorities, other than those in English, have not occurred to them. Hence works of some rarity, like Le Blanc's Treatise on the Coins of France, or of great commonness, like the New France of Charlevoix, which latter, as we shall soon proceed to show, contains most satisfactory corroboration of the American character of the coin of Louis Quatorze before us, with a tolerably ample history of it, have equally escaped their notice. As John Smith's History of Virginia, on the other hand, includes a full account of the Sommer Islands pattern, and is a familiar book, in English, they have, through a natural confusion of localities, inadvertently come to regard that coin as a United States "Colonial" one.

Moreover, this GLORIAM REGNI, or French-American piece of Fifteen Sous, is a very rare coin. I infer from the first of the two French authorities whom I have named—and I shall presently quote his exact words—that only one hundred thousand livres' worth of 15-sous pieces and 5 sous pieces, together, was struck in 1670, and none at any subsequent date. The "livre," now obsolete, was one-eightieth less in value than the present franc, and, like the franc, contained twenty sous. Personally, I know of the existence of only five specimens. I have had the good fortune to obtain two, both in very fine condition, from two different auction-sales of coins in Europe, and one of these I have now the honor of presenting to the American Philosophical Society, with an accompanying wood-cut made expressly for the illustration of this paper; a third, seemingly in a poor state of preservation, if we may judge from its heliotype likeness in Mr. Crosby's work, plate III, No. 5, is in the cabinet of that accomplished scholar and numismatist, William S. Appleton, of Boston; the fourth had, from its appearance, and the locality where I met with it, in all probability been circulated in America. It was in the collection of Mr. J. Myshrall, at Frederickton, New Brunswick, where I saw it in 1870, towards the end of the summer. It showed marks of rough treatment, and must, I think, in passing from hand to hand, have reached, from Lower Canada, the town where it came under my observation. The fifth has been shown me since I began to write this communication, by its owner, Mr. Henry Mott, at present of Brooklyn, but formerly of Montreal.

It bears slight marks of circulation, and was obtained in the latter city. Hence it too, probably, was once in actual use.

And here I have a remark to make: that it is a somewhat unreasonable, albeit almost universal, trait of collectors of coins, to strive to obtain them in a condition, if possible, uncirculated, or at least nearly approaching that state. Yet it is evident that marks of actual service, provided they have not obliterated the legend or seriously impaired the device, ought to give a heightened interest to these objects, as proving them to have been handled by the people of their time. The desire to possess a collection, which, in mechanical and artistic beauty and brilliancy, may compare favorably with others, seems, however, to transcend, with most numismatists, every other consideration; and accordingly a coin, which may be called still-born, inasmuch as it has, by some accident, been snatched from a coin's virtual existence, which is its circulation, on the very threshold of such real life, has always commanded, and will continue to command the preference.

But it is now time to authenticate our GLORIAM REGNI, and establish, by evidence, that it is entitled to the estimation which we claim for it. In the "Historic Treatise on the Coins of France, from the commencement of the Monarchy to the present time," by Mons. Le Blanc, Paris, 1703, we read at page 388: "In order to facilitate commerce in Canada, the King caused to be struck a hundred thousand livres' worth of Louis of 15 sous, and of 5 sous, and Doubles of pure copper. These coins were of the same value, weight, and fineness with those of France. On the silver Louis of 15 sous and 5 sous, in place of the *Sit nomen Domini benedictum*, there was *Gloriam regni tui dicent*, and on the Doubles, *Doubles de l'Amerique Françoise.*" The specimen which I transmit to the Society, must therefore, as its size and intrinsic value denote, be one of those of Fifteen Sous. I am much inclined to doubt whether the Louis of five sous was really struck, since I have never seen one or heard of one as actually existing. Nor is any "Double" to be found, as far as I know, among American collectors, though the inhabitants of Lower Canada and of the French West India Islands have in all likelihood preserved some few examples. Mr. Crosby's heliotype portrait of the piece, plate III, No. 6, is as he informs us, not taken from a genuine one.

In a letter written at Quebec, Feb. 15, 1721 (Nouvelle France, Vol, III, p. 91), Charlevoix gives us the following information on our subject: Commerce in Canada was depressed by nothing perhaps more than "the frequent changes which were made there in the coins. I will give a brief account of the matter. In 1670, the West India Company, to which the King had ceded the dominion over the Islands of the French American Continent, had permission to introduce into the Islands small money to the amount of a hundred thousand francs, stamped by a particular die, with a legend which was peculiar to it. The King's edict is of the month of February, and was to the effect that these coins should be current only in the Islands. But on certain difficulties, which supervened, the Council

issued, on the 18th of November of the year 1672, a decree by which it was ordered that the money aforesaid, and all other specie, being current in France, should also be current, not only in the French Islands but also on the terra-firma of America subject to the crown, with an augmentation of one-fourth superadded; that is to say, the pieces of fifteen sous for twenty, and the others in proportion."

"The same decree ordered that all contracts, bills, accounts, purchases and payments should be made between all descriptions of persons, in money, without privilege of barter or accounting in sugar, under penalty of nullity as to transaction. And in regard to the past, it was ordained that all stipulations relating to contracts, or bills, or debts, or obligations, or rents in sugar and other provisions should be reduced into and made payable in money, at the valuation of the aforesaid coins. In execution of this decree, coin increased one-fourth in value in New France," &c., &c. Here we leave the amiable Jesuit to relate the financial mischief which ensued, and we quit the historic aspect of our theme for the æsthetic and literary.

As a work of art this coin is beautiful. It will, from that point of view, compare advantageously with any now produced in the home-mints of this country, where it was once intended to circulate. The portrait of Louis presents him as a handsome man of thirty-two, his age in 1670; the mint-mark of the sun in splendor recalls his famous motto: "*Nec pluribus impar*"—which, by the way, has a structural similarity to our own national one;—the manner of marking with a · subscript the final I in XIIII is very uncommon; I know no other instance of it on a coin. The reverse offers us, as a subject of remark, first, the legend: "*Gloriam Regni tui Dicent.*" It is taken from the vulgate of the fine Psalm CXLV., entitled "David's Psalm of praise." Verses 10–13 of our translation read as follows:

10. All thy works shall praise thee, O Lord; and thy saints shall bless thee.
11. *They shall speak of the glory of thy Kingdom*, and talk of thy power;
12. To make known to the sons of men his mighty acts, and the glorious majesty of his Kingdom.
13. Thy Kingdom is an everlasting Kingdom, and thy dominion endureth throughout all generations.

In the application of the beginning of verse 11 to the purpose of a numismatic legend, particularly if it be considered in connection with its context, two covert references seem to me to be intended; the first, to the highly ecclesiastical character of French colonization in America, in which exploration and conversion ever proceeded hand in hand; the second, to the "mighty acts" and "glorious majesty" of the "grand Monarque." It is true that he had not, at this comparatively early epoch in his reign, put forth the exaggerated pretensions which he afterwards advanced; but the adulation and irreverence which offend us in the use made of these words, were already in the taste and fashion of that day.

Our second subject of remark is the crowned A (such we take it to be) which appears above the royal crown which forms the armorial crest. In

the absence of any authoritative information on the subject, we may reasonably conjecture that it signifies French (or Royal) America, and, if this be so, the only characteristic needed to make this coin pre-eminent in interest among all American colonial pieces, that, namely, of having on its face a distinct mention of our Continent, is supplied.

In concluding this paper, of which the subject, and the treatment of the subject, will, it is hoped, not be found beneath the notice of the American Philosophical Society, the writer may be permitted to observe that the fact of its being presented in this our year of Jubilee, and at the moment whence, a century ago, our first grand "annorum series" began to proceed, is entirely accidental, resulting from the casual acquisition, at this time, of the specimen which accompanies it. There seems, however, to be an eminent propriety in calling to mind, on the present most interesting occasion, and also connecting with tangible objects of curiosity, however slight, the American history of the great ally who rendered such essential aid to the insurgent colonies during their doubtful struggle. In regard to matters like this, perhaps not likely to be remembered with sufficient tenacity, medals and coins perform an important service; while, to take a broader view, through their distinct marking of decisive epochs, they contribute to enable us, in the words of a writer of the illustrious nation referred to, "*vivre de la grande vie des siècles*"—to live in the great life of the Centuries.

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*On some Fundam ntal Propositions of Central Force.**

By Pliny Earle Chase, LL.D.,

Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, July* 21, 1876.)

All cyclical motions which are produced by the action of a central force are, necessarily, of an oscillatory character. They may, therefore, be mathematically represented by suitable modifications of simple pendulum equations, as Fourier has well shown.† The first attempt at a general discussion of such motions seems to have been made in 1827, by Dr. Henry James Anderson, Professor of Mathematics and Astronomy in Columbia College, whose paper‡ may be found in the third volume of the second series of the

* Whenever I speak of "central force," in the present paper, I refer to force varying inversely as the square of the distance.

† See, also, papers by David Rittenhouse, Trans. Soc. Phil. Am., iii; Jos. Clay Ib., v; Owen Nulty (suggested by Rittenhouse's), Ib. [2] i; James Dean, and N. Bowditch, Trans. A. A. S., iii; Robert Adrain, Trans. S. P. A., [2] i; Eugenius Nulty, Ib. [2] ii.

‡ "On the motion of Solids on Surfaces, in the two Hypotheses of perfect Sliding and perfect Rolling, with a particular examination of their small Oscillatory Motions." *Op. cit.* p. 315.

American Philosophical Transactions. The following quotation from his exordium is both prophetic and suggestive :

"There are few branches of Mechanical Philosophy as interesting in every point of view as the theory of Oscillatory Motion. From the minutest vibrations of a harp-string to the magnificent oscillations of a planet's axis, there are an infinite number of analogous phenomena remarkable for their curious properties or important uses. The common pendulum, that little instrument which has rendered such essential service to science and the arts, and will soon, in the hands of the skilful observer, unfold to us the internal constitution of our globe, and give a clue to the process by which it has acquired its present state, is itself indebted for its accuracy to the incessant superintendence of a watchful mathematical analysis. The science of Acoustics in all its parts, the varied phenomena of the tides, the theory of Saturn's ring, that wonder of the solar system, and the philosophical explanations of the stability and harmony of the celestial motions, are in fact, but different applications of this extensive branch of Demonstrative Mechanics. What adds to the interest and value of this subject is the circumstance that a large class of oscillatory motions, namely those of any rigid system whatever whose points depart but little from the position which they occupy when at rest, has been found susceptible of complete determination, by means of which the position of the bodies composing the system may be expressed (to use the language of analysis) in finite functions of the time."

In 1843, Professor Stephen Alexander communicated to the American Philosophical Society,* his observations upon physical phenomena which accompany eclipses. Among those phenomena was a "dragging of shadows," which he attributed, at the first meeting of the American Association (Philadelphia, 1848), to the inertia of the luminiferous æther. By this, and other like "scientific uses of the imagination," he was led to the discovery of a series of cosmical relations, some of which were laid before subsequent meetings of the Association, the whole being finally embodied in his "Statement and Exposition of Certain Harmonies of the Solar System."†

At the second meeting of the American Association, (Cambridge, 1849), Professor Benjamin Peirce read a paper "On the Relation between the Elastic Curve and the Motion of the Pendulum." "On this subject Prof. Peirce remarked, that the relations discovered merely by intellectual investigations, and not observed by the senses, are of peculiar interest, as manifesting the fact that one intellect presides over the production of those phenomena. Could we see in the moon a house like our own, we should say that it was built by men like ourselves, having similar wants, and using similar means to supply them, and we should say that the same being who formed our minds created theirs also. We cannot make such observations, but we may trace relations between objects with which we are

* Proc. Soc. Phil. Amer., May, 1843, vol. iii.

† Amer. Nat. Acad. Sci., 1873-4; Smithsonian Contrib., 280.

familiar, which lead us to similar results. At present the discovery of these relations has been very much confined to those subjects to which mathematics apply."* At a later session of the same meeting, Peirce presented a "Mathematical Investigation of the Fractions which occur in Phyllotaxis." After showing the influence of an identical law in the arrangement of plants and planets, he asks: "Whence could this extraordinary coincidence have arisen but from the action of a single mind? and what does it indicate but that the same Word which created the planet, is expressed in the planet? May I close with this remark, that the object of geometry in all its measuring and computing, is to ascertain with exactness the plan of the great Geometer, to penetrate the veil of material forms, and disclose the thoughts which lie beneath them? When our researches are successful, and when a generous and heaven-eyed inspiration has elevated us above humanity, and raised us triumphantly into the very presence, as it were, of the Divine intellect, how instantly and entirely are human pride and vanity repressed, and by a single glance at the glories of the infinite mind, we are humbled to the very dust."†

On the second of January, 1849, in a communication "On the Fundamental Principles of Mechanics,"‡ Peirce had already shown that "a system of bodies in motion must be regarded mechanically as a system of forces or powers which is a perfect representative of all the single powers of which the system is compounded, and this, too, at whatever time or times the component powers may have been introduced into the system. The question of the simultaneous introduction of the partial powers is of no importance. Any power which is at any time communicated to the system is preserved in the system unchanged in amount or direction."

At the same meeting of the Academy, Professor Joseph Lovering read a paper "On the Law of Continuity,"§ in which he said, "the method of analysis which began with Leibnitz and Newton, and which in England has been known under the name of fluxions, rests upon this law of continuity. If we admit the usefulness of the principle only in cases of motion, we still give it a wide range; since so many problems, not strictly dynamical, are reduced to cases of motion when investigated by the rules of modern analysis."

On the 4th of Feb. 1851,‖ "Professor Peirce gave an argument, which he thought to be new, against the principle which is usually adopted in theoretical works, that the force of a body in motion is its *vis inertiæ*. He believes, on the contrary, that the time is at hand when the *vis viva* will be universally recognized as the force of a moving body. His new argument is derived from the effect of a force in causing rotation, as well as translation. By the old theory, no additional force is required to produce rotation; whereas, by the theory of the *vis viva*, just as much force is re-

* Proc. A. A. A. S., ii, 129.
† Ib., p. 446.
‡ Proc. A. A. S., ii, 111.
§ Ib., p. 121.
‖ Ib., p. 256.

quired as is actually exhibited in the resulting rotation. The same argument may be derived in another form from the vibrations of elastic bodies."

The "Mathematical Monthly," for January, 1859, contained an exhaustive discussion of "The Motions of Fluids and Solids relative to the Earth's surface," by Professor William Ferrel, some of the results having been published about two years before, in the "Nashville Journal of Medicine and Surgery." The recent great advance in meteorological knowledge and in successful weather prediction is due, in great measure, to the publication of Ferrel's laws.

In 1861, Professor Simon Newcomb presented to the American Academy, a compendious review of the dynamical theory of gases.* His paper contains, among other matters of interest, the following first approximation towards a theoretical establishment of the empirical ratio between the temperatures under constancy of pressure and under constancy of volume: "7. If the particles were perfectly hard and spherical, the specific heat under constant volume would be to that under constant pressure as 3 to 5. If they were hard, but not spherical, this ratio would be that of 3 to 4. The latter result follows from an elegant theorem given by Professor Maxwell in Vol. XX, of the Philosophical Magazine, viz., that if the particles are hard, but not spherical, the sum of their *vires vivæ* of translation will be equal to that of their *vires vivæ* of rotation."

My first attempt at applying the foregoing principles was made in 1863,† when I showed that the daily fluctuations of the barometer are of such form and magnitude as can be explained by the combined action of atmospheric inertia, terrestrial resistance, and *motion* relative to the Sun. I also showed that the tendencies to equality of areas, in the daily and yearly fluctuations, furnish the data for a close approximation to the solar distance.‡

In 1864, Professor James Edward Oliver made a practical investigation of the best approximate representation of all the mutual ratios of k quantities by those of simple integers, drawing illustrations especially from phyllotaxis and planetotaxis. His investigation assumed that "Nature, while obeying with absolute precision the resultant of her efficient laws, such as Inertia, Attraction, etc., falls into forms which commonly both *utility* and *taste*, often independently of each other, would prescribe."§

In 1865, Ferrel described an annual variation in the daily mean level of the ocean, the greater part of which he attributed to "a tangential force arising from the motions of the ocean combined with the motion of the Earth's rotation. It was first brought out in its most general form in [his] paper on the motions of fluids and solids relative to the Earth's surface."‖

* Proc. A. A. S., v, 112.

† Proc. Soc. Phil., Amer., ix, 283.

‡ Ib., *loc. cit.*, and x, 376. See, also, Ferrel's paper of 1865, to which reference is made below.

§ Ib., vi, 288.

‖ Ib., vii, 35.

A few days ago, Dr. Thomas Hill, Ex President of Harvard College, illustrated the danger of exalting science above philosophy. "The true aim of science is not merely to record the uniformities of nature, but to discover the intellectual ideal which binds them together. The human mind in the presence of phenomena * * * is always inclined to ask three questions: What is the invariable order of sequence? What cause produces the effect? For what end are they produced?"*

Each of these papers involves one or more of the following postulates, which are treated by many as scientific heresies, but which others regard as prolific truths.

1. Faith and Reason are both handmaids of Science.

2. Knowledge is not only power, but it is also supreme power, or the source of all power.

3. Order and harmony are evidences of Intelligence. The discovery of new harmonies should, therefore, always stimulate new scientific investigation.

4. There can be no law without a Lawmaker.

5. Unity of Intelligence indicates unity of law.

6. Æsthetic gratification points to efficient laws.

7. All empirical results rest on *a priori* principles.

8. The methods, are permanently recorded in the works, of Intelligence.

9. There can be no unbalanced physical force without motion Even forces which are *relatively* static, can only be fully studied when producing motion.

10. Simple physical force is always central. Therefore the laws of elasticity and of oscillatory motion are of prime importance in all fundamental physical investigations.

11. Any æthereal medium, through which impulses are progressively transmitted, must be material.

12. Any medium through which impulses are transmitted instantaneously,† must be devoid of inertia, and therefore spiritual.

13. Tendency of motion is always in the direction of least resistance. Radial and tangential oscillations naturally alternate.

14. If the force of a moving body is its *vis viva*, the average *vis viva* of a perpetual oscillation is the proper standard for determining its quantity of motion, and the average velocity is the velocity of an equivalent synchronous oscillation under uniform velocity.

Most of these postulates, like all hypotheses, theories and laws, fall within the domain of metaphysics. Physical science, properly so called, is limited to facts which are discoverable by the senses, and to their co-ordination in accordance with metaphysical requirements. Pure metaphysics tends to

* Address before the Alumni of Bowdoin College, July 12, 1876.

† The only instance of supposed instantaneous transmission is that of gravitating action. La Place's estimate of its least possible velocity has been variously and sometimes wrongly stated; in his *Mécanique Céleste*, X, vii, 22, he fixes it at 100,000,000 times the velocity of light, and says, "therefore mathematicians may continue to regard it as infinite."

dreaminess and paradox ; pure physics, if such a thing were possible, to worldliness and shallowness. Metaphysics strives to learn too much ; physics is satisfied with too little. Science deals both with the physical and with the metaphysical ; embracing all knowledge that bears, in any way, upon the religious, the ethical, or the intellectual needs of man. An exclusive regard to either phase of our triune nature leads almost of necessity, to shortsightedness and narrowmindedness. In the modern science of thermodynamics, the fertility of discovery, which has rewarded the labors of European and American investigators, furnishes abundant evidence of the usefulness of metaphysical anticipations as aids to physical research.

Newton looked to æthereal oscillation as a probable source of gravitation, finding it easier to imagine the approach of inert bodies through the influence of elastic thrusts, than to conceive of any practicable form of pull; Le Sage, adopting Newton's view, developed it with considerable detail, and later French Academicians have shown, in various ways, and to various extents, the likelihood of the hypothesis ;* Anderssohn has given an experimental demonstration of its sufficiency ; Norton and Challis have engaged in similar speculations, which they have extended so as to embrace all known forms of force ; Weber, Kohlrausch, and Clerk Maxwell have confirmed Faraday's partial identification of light and electricity by actual measurement ;† Faraday's cautious suggestion of "lines of force," proposed to treat all forces mathematically and independently of any hypotheses as to their nature, a proposal which has been largely and wisely followed by many recent investigators. As a further contribution towards such treatment I submit the following propositions, to which I have been led in the progress of my own researches, and which may be serviceable in other investigations.‡

Let f = velocity communicable, at distance r in time t, by any central force varying inversely as r^2.

f' = velocity communicated by a single impulse or in a single instant.

$f_i = if'$ = " " by i equal impulses, or in i instants if the distance remains constant. Then

I. If the pressure resulting from f is constant, it must either be exactly

* For some of the most important of these papers, see references of W. B. Taylor, in Journal of the Franklin Institute, cii, 71.

†The 9th postulate may, perhaps, be made still more general by this measurement. That we know no instance of absolutely static force, is indisputable ; the communication of momentum or *vis viva* by any physical agency which has no momentum nor *vis viva* is, to me, inconceivable ; the consideration of electrostatic force as force static relatively to the Earth, and of electrodynamic force as force moving with the velocity of light, furnishes almost demonstrative evidence of a universally oscillating æthereal medium which may be the secondary or physical source of all physical motion and all physical force.

‡Most of the propositions of Newton's Principia are applicable to all central forces.

counterbalanced by some opposing force or forces, so as to produce relative rest ; or the motion must be maintained at a constant distance from the centre, so as to produce circular revolution ; or, if the opposing force results from the transformation of interfering revolutions, the two conditions may be combined so as to produce rotation. The velocity of circular revolution $= \sqrt{fr}$; the velocity of rotation $= \sqrt{fr} \div n$. The value of n may be found by experiment, or, if the aggregating impulses are homogeneous, it may be easily calculated, as will be subsequently shown (V–VII).

II. If the pressure is varying, and so exerted as to produce radial motion, directly towards the centre, the velocity acquired, at any given distance ρ, may be found by the equation $v_\rho = \left\{ \frac{2fr(r-\rho)}{\rho} \right\}^{\frac{1}{2}}$. Therefore, if the theory of Boscovich were true, at the centre, where $\rho = 0$, v_ρ would be infinite.

III. If the varying pressure, or pull, leads to perpetual radial oscillations, synchronous with perpetual circular oscillations under constant pressure, or pull, the extent of the radial excursions from the centre is $2r$, and the mean velocity of radial oscillation (Postulate 14) is $\frac{2}{\pi}\sqrt{fr}$. The equation $\frac{2}{\pi}\sqrt{fr} = \left\{ \frac{fr\,(2r-\rho)}{\rho} \right\}^{\frac{1}{2}}$* gives $\rho = \frac{2\pi^2 r}{\pi^2+4} = 1.4232r$.

IV. Since the *vis viva* of a moving particle varies as $\frac{1}{r}$, the *vis viva* at the radius of average radial velocity in a rectilinear orbit, : the *vis viva* at the radius of synchronous circular velocity : : 1 : 1.4232.

V. If the constrained synchronous rotation of particles in a spheroid, and the free revolution of exterior particles, are due to the same primitive æthereal impulses (I), the uniform velocity of those impulses is the *limiting* velocity, towards which both motions tend when their circular paths are indefinitely diminished. Let, therefore, $v_1 = \sqrt{fr} \propto \sqrt{\frac{1}{r}}$ = velocity of free equatorial revolution ; $v_2 = \frac{\sqrt{fr}}{n} \propto \frac{1}{r}$ = constrained velocity at the same point = velocity of superficial equatorial rotation. Then $v_0 = \left[v_1\right] = \left[v_2\right] = nv_1 = n^2 v_2 = n\sqrt{fr}$ = limiting tangential velocity, both of revolution and of rotation, under a reduction of spheroidal volume to an equatorial radius $\frac{r}{n^2}$. Under such reduction, all the particles in the equatorial plane would have the velocity of free revolution, or of perfect fluidity.

*Since $f \propto \frac{1}{r^2}$, the substitution of $2r$ for r_0 gives $fr\,(2r-\rho) = 2f_0 r_0\,(r_0 - \rho)$.

VI. If contraction were to go still further, the centrifugal force of rotation would give the nucleal particles orbits of increasing ellipticity. These orbits would finally become infinite, when the average linear motion was equivalent to parabolic perifocal motion; or, in other words, when the mean linear velocity, $\frac{2}{\pi}\left[v_2\right] = \left[\sqrt{2fr}\right]$. These velocities tend to or from coincidence at $\frac{2r}{n^2\pi^2}$; for $\frac{n^2\pi^2}{2} \times \frac{2}{\pi} \times \frac{\sqrt{fr}}{n}$ $= \frac{n\pi}{\sqrt{2}}\sqrt{2fr} = n\pi\sqrt{fr}$. We thus find that the limiting velocity between complete dissociation and incipient aggregation ($n\pi\sqrt{fr}$), is $\pi \times$ the limiting velocity between complete aggregation and incipient dissociation ($n\sqrt{fr}$; see V.)

VII. Let t = time of describing $\frac{1}{2}r$, in virtual approach to the centre, under the action of any central force f, = time of describing r in circular revolution, or motion under constant pressure. Then $ft = \sqrt{fr}$; πt = time of free semi-circular oscillation; $n\pi t$ = time of constrained semi-circular oscillation = time of semi-rotation; $n\pi ft = n\pi\sqrt{fr}$ = velocity acquired in the time of semi-rotation = *radial limiting* velocity (V, VI). Therefore the velocity of any central impulses which are capable of producing aggregation, free revolution, and constrained rotation = velocity produced by constant equatorial pressure acting for one half-rotation.

VIII. Radial oscillations, through a radius $\rho = mr$, give the central dissociating velocity $\left[\sqrt{2fr}\right]$ at $\frac{mr}{m+1}$.

IX. Undulations in elastic media tend to generate other undulations, in arithmetic, geometric, harmonic and other figurate progressions.

X. The limiting radius of free revolution (or the atmospheric radius in nebular condensation) varies as $t^{\frac{2}{3}}$; the limiting radius of constrained rotation (or the nucleal radius) varies at $t^{\frac{1}{2}}$. Therefore the nucleal radius $\propto \frac{3}{4}$ power of the atmospheric radius. In ordinary discussions of the nebular hypothesis, planetary aggregation has been regarded as atmospheric, under a velocity varying as $\sqrt{\frac{1}{r}}$; but there are many traceable evidences of simultaneous nucleal activity, under a velocity varying as $\frac{1}{r}$.

ILLUSTRATIONS.

Electrodynamics and thermodynamics furnish numerous illustrations of Prop. I, but some of its most obvious exemplifications are found in cosmical revolution, atmospheric elasticity, axial rotation, and in the various applications of Ferrel's laws.

Proposition II identifies all central forces, so far as an identical ideal limit of velocity is concerned. It is true that the ideal limit is physically unattainable, but a full development of Peirce's theory, of *vis viva* and simul-

taneous rotation and transmission,* will doubtless contribute to the proper determination of data for finding the practicable equivalent, in any given case.

According to the dynamical theory of gases, the average radial velocity, which is found by Prop. III, is the velocity which represents constancy of volume, in any aggregation of a homogeneous elastic fluid.

We have already seen (I) that *dynamic* constancy of pressure produces the velocity of circular revolution; and by the principles of thermodynamics, specific heat varies as *vis viva*. Prop. IV, therefore, furnishes an exact mathematical accordance with the empirical ratio between heat of constant volume and heat of constant pressure,† the representative of constant pressure in a perpetual radial oscillation, being the radius of mean excursion; the representative of constant volume, the radius of mean velocity; while the *vires vivæ*, of circular revolution due to constant pressure and of circular revolution maintaining constant volume, are inversely as their respective radii. Newcomb showed‡ that if there is actual collision of particles, they can neither be perfectly hard and spherical, nor hard and not spherical. There must, therefore, be elasticity or something analogous to elasticity, either in the gaseous particles themselves, or in their relative motions. Peirce's views, together with the fact that *vis viva* varies as the quantity of motion, (the quantity of motion, in perpetual oscillation under uniform resistance, being proportional to the average velocity), seem to involve the probability that there is no absolute collision, but the phenomena are due to simple motions, and are independent of the nature of the particles themselves. The *vis viva* of constant circular velocity varying inversely as radius, the product of such *vis viva* by radius, for any given central force, is a constant quantity.§

Prop. V may perhaps prove suggestive, in the study of the mechanical differences between fluidity and solidity, and of the laws of chemical combination, as well as in the elucidation of the nebular hypothesis, of which some illustrations are given below. I have already shown‖ that Alexander's planetary ratio, 1.8, which is the $\frac{5}{3}$ power of the thermodynamic ratio 1.4232, appears in the explosive energy of H_2O, and that this energy is directly traceable to the limiting velocity of synchronous rotation and revolution¶ under the same primitive impulses (I, III).

If the central force f, in Prop. VI, is solar gravity, the limiting velocity $(n \pi \sqrt{fr})$ of uniform impulses which account for solar and planetary

* *loc. cit.*, Feb. 4, 1851.

† The principal estimates of $\frac{c}{c'}$ are: Guthrie, Regnault, 1.41; Masson, 1.419; Tyndall, 1.421.

‡ *loc. cit*, 1861.

§ The various *vires vivæ* considered in the present paper are:

v. v. of interior nucleal rotation in an unchanging nucleus, varying as r^2;

v. v. at any point within a homogeneously expanding or contracting nucleus, varying inversely as r^2;

v. v. of free revolution communicable by interior nucleal rotation in an unvarying nucleus, varying as r;

v. v. of free revolution due to fall towards, or repulsion from centre, varying inversely as r.

‖ Proc. S. P. A., xii, 394. ¶ Ib., and xiii, 142.

aggregation, solar rotation, and planetary.revolution, is *the velocity of light.** For, Sun's distance from Earth being 214.86 solar radii, the velocity of light $= \frac{214.86r}{497.825} = .4316r$ per second. Equating this value with $n\,\pi\,\sqrt{fr}$ and substituting the value of $\sqrt{fr} = \sqrt{gr} = 2\,\pi\,r \times 214.86 \div (365.2564 \times 86400) = .000627049r$ per second, we find $n = 219.0894$, and $v_2 = \frac{\sqrt{fr}}{n} = .0000028622\,r$ per second. On comparing this result with the estimates from observation of Sun-spots, we find it is about $\frac{2}{5}$ of one per cent. greater than Schwabe's estimate (.0000028511), while it is about $\frac{1}{4}$ of one per cent. less than the average of Spörer's greatest (.0000029533, in lat. 1° 45′) and least estimates (.0000027863, in lat. 24° 38′). All other estimates are embraced within Spörer's limits, and most of them agree very nearly with Schwabe's. Such closeness of exemplification in gravitating action, may well encourage a search for others in chemical association and dissociation.

Inasmuch as Prop. VII is a corollary of Prop. VI, it may be practically illustrated by the same examples. It has, however, an additional interest, by showing that the radial impulses continue their efficiency, within the rotating mass, until they are able to proceed, without interruption, in the same direction in which they entered the system. It also lends confirmation to the above values of n and v_2.

Prop. VIII accounts for the coefficients of planetary distances, in the abscissas of my Stellar-solar parabola† of which I offer a new form in my remarks on Prop. X.

The various planetary harmonies which have been pointed out by Titius, Bode, Alexander, Peirce, Kirkwood, and myself, furnish abundant *a posteriori* corroboration of Prop. IX.

Obermayer's Law (Trans. Vienna Acad.; quoted in *Nature*, June 1, 1876, p. 119), that the friction-coefficient of permanent gases varies as the $\frac{3}{4}$ power of the coercible gases and as the absolute temperature, seems to fall under Prop. X, as a particular case of the nucleal and dissociating influences of central force. The planets furnish various other cases, under the same proposition, illustrating Peirce's views as to the constancy of the quantity of motion, or *vis viva*, in a system, Oliver's æsthetic theorem, my planetary pendulums,‡ and nearly all of the postulates.

The time of terrestrial rotation being 86400 seconds, and the time of free revolution at the equator $(2\,\pi\,r \div \sqrt{gr})$ 5074 seconds, the *vis viva* of revolution is $\left[\frac{86400}{5074}\right]^2 = 289.68$ times the *v. v.* of rotation at the same point. If this is the *v. v.* at the limit between complete aggregation and incipient dissociation, the *v. v.* at the limit between complete dissociation and incipient aggregation (VI, VII,) is π^2 times as great. Therefore, if Earth's

* Ib. xi, 103, and subsequent papers.

† Ib., xii, 523.

‡ Proc. Soc. Phil. Amer., xiv, 612, 622, sq.

motions represent *nucleal* formative force, the velocity of rotation at the latter point should be $\frac{1}{\pi^2} \times \frac{1}{289.68} \times \frac{2\pi r}{5074} = .0000004331r$ per second.

We have already seen (V) that the solar equatorial velocity at the lower limit is $\frac{1}{\pi}$ the velocity of light, or $.1374r$. But in perpetual nucleal rotation the communicable interior *v. v.* varies as the velocity, or as radius, and in circular revolution the mass $\propto$ *v. v.* $\times r$. Therefore if we refer the solar and terrestrial motions to the same nucleal radius, we get, for their respective masses, the proportion; Sun : Earth : : .1374 : .0000004331 : : 317,500 : 1. This represents a solar parallax of 8″.924 and a distance of 91,600,000 miles.

Applying a similar test to Jupiter's motions, we find no evidence of nucleal formative action, but a close approximation to atmospheric force synchronous with the Earth-aggregating nucleal force.* The identity of value in the two forces may be shown as follows:

The velocity of revolution, at Sun's equator, is $\frac{2\pi \times 91,600,000}{214.86 \times 10020.24} =$ 267.3265 miles per second. If this is the fundamental formative velocity for Earth and Jupiter, Earth's time of semi-rotation (VII) should be $\frac{267.3265 \times 5280}{32.08} = 43998.86$ sec.; and Jupiter's, $\frac{11.08^2}{302.98} \times 43998.86 =$ 17826 sec.; representing a Terrestrial day of 24 h. 26 m. 37.72 sec., and a Jovian day of 9 h. 54 m. 12 sec. Earth's rotation-velocity, therefore, appears to have been accelerated about 2 per cent., and Jupiter's retarded about $\frac{1}{3}$ of 1 per cent. (according to Herschel's estimate of 9 h. 56 m.), since the "Beginning," when the Creative Word simultaneously established their nucleal foundations. Similar relations would hold if the Jovian and Telluric rings were formed at the same time, and the terrestrial nucleus did not appear till the inner ring had been slightly condensed.

If we assume Earth's present limiting velocity (VII) as the indicator of aggregating force, we have $n\ \pi\ \sqrt{fr} = 43200 \times 32.08$ ft. $= 262.47$ m. per sec. The solar modulus of light,† at the principal centre of gravity of our system (*c. g.* ⊙ and ♃), is 505400 solar radii. Therefore the nucleal-formative $v = \sqrt{505400} \times$ the atmospheric v, and when the nucleal v was the v of light ($.4316r$), the atmospheric $v = .0006071r = 262.47$ m. This would make Sun's distance $(214.86r) = 92,891,300$ m.

Since the velocity of primitive nucleal rotation varied within the nucleus as r, communicating a similarly varying *vis viva* to the shrinking nucleus, the above indicator gives, as the theoretical time of solar rotation, $365.256 \div \sqrt{214.56} = 24.912$dy., which implies an equatorial velocity of $.0000029192r$ per sec. Astronomical observations, and Props. VI, VII, and X, therefore,

*Hence, perhaps, the similar density of Sun and Jupiter.

†$v = \sqrt{2fr}$; ∴ r, or *modulus*, $= v^2 \div 2f$. This involves Alexander's postulate of æthereal inertia.

furnish the following approximations to the rotation velocity, the unit being one ten-billionth of Sun's radius:

Spörer, maximum.	Nebular action.	Light action.	Schwabe.	Spörer, minim.
29533	29192	28622	28511	27863

According to the same indicator, the present height of possible solar atmosphere, or the radius of equal centripetal and centrifugal solar force should be $(214.86)^{\frac{2}{3}} r = 35.873\, r$; the time of planetary revolution at Sun, $1yr \div (214.86)^{\frac{3}{2}} = 10020.242$ sec.; the present limit to the velocity of constant pressure, $2\pi r \div 10020.242 = .000627049\, r$ per s; the present solar modulus of light, $(.4316 \div .000627049)^2 r = 473755.65\, r$; the present modulus atmosphere, $35.873 \times 473755.65 = 16995141 r$.

If we locate the Stellar-solar paraboloid by a vertex at $\frac{1}{\pi}$ solar radius, (the primitive locus of complete association), and an abscissa ($x_{35.873} = 35.873 \times$ modulus) at the present surface of modulus-atmosphere, the general equation, $x_n = \xi\, \eta \pm n\, \zeta\, n^2$, furnishes 9 abscissas between Sun and Mercury, and 9 between Neptune and a Centauri, the central 9 representing points of dissociating planetary velocity (VIII), as will be seen by the following table of secular elements:

n	Log.	x_n	Perihelion.	Mean.	Aphelion.
9.873	$\frac{3}{4}$ ☿	1.6774	1.6806	1.7950	1.8855
10.873	$\frac{1}{2}$ ♀	1.9099	1.8586	1.8905	1.9200
11.873	$\frac{2}{3}$ ⊕	2.1541	2.1256	2.1561	2.1845
12.873	$\frac{3}{4}$ ♂	2.4102	2.3248	2 3901	2.4468
13.873	$\frac{4}{5}$ Ast.	2.6779			
14.873	$\frac{5}{6}$ ♃	2.9575	2.9420	2.9692	2.9949
15.873	$\frac{6}{7}$ ♄	3.2488	3.2064	3.2447	3.2799
16.873	$\frac{7}{8}$ ♅	3.5519	3.5217	3.5571	3.5897
17.873	$\frac{8}{7}$ ♆	3.8668	3.8614	3.8678	3.8740
36.873	a Cen.	7.6622	7.6571		7.6860

The tabular logarithms for a Centauri (7.6571 and 7.6860) represent, respectively, the least and greatest estimates of its distance that have been made. The values of the secular planetary perihelia and aphelia are taken from Stockwell's "Memoir on the Secular Variations of the Elements of the Orbits of the Eight Principal Planets" (Smithsonian Contributions, 232, pp. 37, 38).

It is of course impossible, under the present limitations of our knowledge, to determine to what slight extent the foregoing calculations should be modified, by allowances for orbital eccentricity and other considerations. It seems likely, however, that the parabolic abscissas (X) are the fittest representatives of primitive nebular condensation and retardation, while the forces of constant pressure within the primitive nucleus furnish the closest approximation to the ultimate light-activity. If this opinion should

be confirmed by the discussions of the late transit of Venus, the accuracy of my chemical estimate of Sun's mass and distance* will be likewise confirmed.

The generalization of Faraday, as corroborated by the measurements of Weber, Kohlrausch, and Clerk Maxwell, is thus extended to include gravitation, as well as electrostatic and electrodynamic action, in the same category of central force with light (VI), by means of an identical limiting *vis viva*. The simple mathematical correlations make the generalization still broader, so as to embrace heat (IV), chemism, cosmical and molecular aggregation, dissociation, rotation and revolution (V–X), and all central forces (I–X).

The Flow of Water Through an Opening in a Pierced Plate.

By Robert Briggs.

(*Read before the American Philosophical Society, November 3d*, 1876.)

The consideration of the subject of the *vena contracta*, or section of a vein of water emerging from an orifice under certain conditions, is made a portion of the proceedings of the Philosophical Society of Glasgow, and appears in their volume X, page 145 et seq. Four papers are published, the first of which is an extract from a letter of William Froude, Esq., C. E., F. R. S., to Sir William Thomson, dated Cheston Cross, Torquay, 20th December, 1875. Mr. Froude is quoted† * * * * "One result I have tried came out well:—The discharge through an introverted cylinder [tube] with keen edge. Here, by theory, the section of the jet ought to be exactly half of the aperture. For the conservation of stream line energy obliges the velocity to be that due to the head, while the conservation of momentum requires that the pressure on the aperture (which is here the sole operative pressure setting in the ultimate direction of the velocity generated) is only sufficient to create as much momentum, say, per second as will be resident in the length delivered per second, of a column of discharge, of half the sectional area of the aperture, if its velocity is that due to the head.

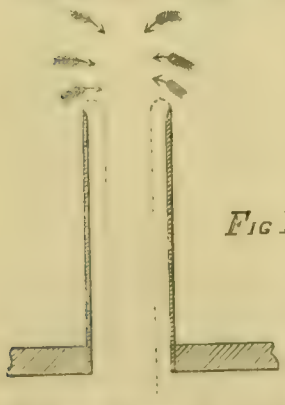


Fig 1

"The cylinder was quite smooth outside and the edge quite keen. The area ratio came out 0.503, 0.502, &c., instead of 0.500, and the little excess was obliterated, if the head was counted, to about one-fourth the diameter below the edge; as indeed it ought to be (I won't swear to the exact figure

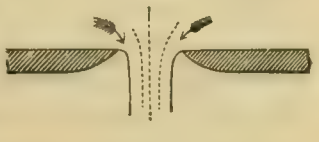
* Proc. S. P. A., xii, xiii, *loc. cit.*

† The entire article is quoted, the hiatus indicated by asterisks exist in the published Proceedings of the Glasgow Society.

one-fourth), because till the motion of the particles is purely parallel to the axis, there must be some accelleration to be effected in the direction of the axis, and this demands the employment of some vertical pressure. * *

"In the *vena contracta* experiment with the thin plates and open air between the plates, the fluid was welcome, if it pleased, to start tangentially to the plane of the aperture as here indicated, and as it appears to do if closely studied. So also with the introverted cylinder; although it was not possible to see what happened I have no doubt that the motion of the particles *next* the edge was vertical upwards, the curvature being only such as the pressure in the contiguous stream would satisfy. If the experiment was not adroitly initiated, the water seized the inner surfaces of the cylinder and run out in an eddied condition, filling the discharge pipe. When, however, it was properly started, the contracted column below issued with beautiful smoothness and symmetry."

Fig 2



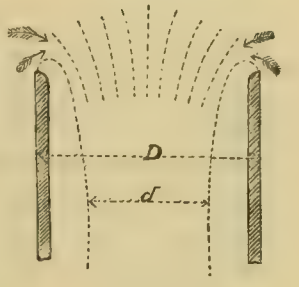


Fig 3

The second paper on the subject is an extract from a letter of Sir Isaac Newton to Professor Cotes, March 24th, 1710–11; from the "*Correspondence of Sir Isaac Newton and Professor Cotes, including Letters from other eminent men,*" published in 1850, by Mr. J. Eddlestone, Fellow of Trinity College, Cambridge, from the originals in the Library of Trinity College. This letter possesses much value as showing Newton's experiment and discussions of the form of the *vena contracta*, and will be found interesting to examine in the proceedings of the Glasgow Society by those who have not ready access to the primary publication. Newton found the *vena contracta* from an aperture in the *side* of a vessel of thin sheet tin plate, five-eighths of an inch in diameter, to have, at the distance of one-half an inch from the hole, a diameter of 21-40ths of an inch. Which was a reduction of diameter of 21-25ths, and of areas of cross section of 0.7058.

A foot note to this letter of Newton by Mr. Eddlestone says, that '*Sectio vena contracta*' was a term used by Jurin, Philosoph. Trans., Sept.—Octo. 1722, p. 185; and that Dan. Bernouilli uses the same term, Hydrodynam., p. 65. Jurin also uses '*vena contracta*'; in all these cases the words denote the reduced section only, while subsequent usage generally applies them to the stream itself as a body, between the orifice and the point of reduced section.

The third paper is a discussion of the *vena contracta* by Professor James Thomson, LL.D., C. E., University of Glasgow, and is a mathematical discussion with six illustrations, intended to demonstrate under certain conditions, as for instance the supposed absence of fluid friction or viscosity, and a supposed great magnitude of vessel and depth of water compared with the dimensions of the orifice, that the jet of water issuing from an

orifice in a thin plate, from a conical adjutage either protruding or re-entrant, has a section, where the stream flows out in sensibly parallel lines, of *more* than half the area of the orifice, and that this condition only ceases for a re-entrant nozzle, in the form of a parallel tube as treated of in Mr. Froude's paper. The conclusions of Professer Thomson do not seem to the writer as warranted by the conditions to which he limits his proposition. The value of the assumed force which he denotes by P is by no means satisfactorily exhibited. As the purpose of this paper is to discuss other points, further notice of Professor Thomson's article may be omitted, only it will be assumed that the reader of this refers to the Glasgow Society's proceedings to see for himself what is set forth by the Professor.

The fourth paper is an abstract of remarks by R. D. Napier, Esq., who gave some consideration of this subject, which was published in 1866, in a pamphlet "*On the Velocity of Steam, &c.,*" in which he made the general assertion, with some qualifications, that the area of the true theoretical *vena contracta* is half that of the orifice. He says, "I have proved in the pamphlet referred to, that the pressure in the plane of the orifice is nearly half the pressure due to the head, and that from thence to the *vena contracta* [the words are here used in the sense of the section of least area] it gradually diminishes to zero. This diminishing pressure causes increasing velocity, and is thus the direct cause of the *vena contracta.* * * * "About three-eighths of the ultimate velocity and five-eighths of the *vis viva* is imparted to the water outside of the plane of the orifice, and it is absurd to attribute these effects either to what I may call the converging momentum being transferred from one side of the orifice to the other, or to the converging particles preventing the free egress of the stream through the orifice, which are the only views hitherto offered to explain the cause of the *vena contracta.*"

This question of the *vena contracta* is a very pretty one in physics, and deserves a more complete and general discussion than it receives in the pages of the Glasgow Society. It should be recognized however, that it does not admit of the simplicity of investigation, either mathematically or experimentally, which the papers of Mr. Froude and Professor Thomson assume. It is impossible to divest the consideration from the fluid friction against the contiguous sides, surfaces, or the edges of the aperture, nor from the fluid friction of the liquid within itself which constitutes *viscosity;* nor yet further, from the frictional resistance to discharge into another medium (the atmosphere in this case); while the absolute strength of water is brought into action in the emerging column to the extent of pressure of the atmosphere. Values for these various elements can be accepted, and the mathematical investigation proceeding from them, would enable a thorough solution of the problem, in place of the extremely partial one essayed in the proceedings of the Glasgow Philo. Soc. Even the effect of dimension of vessel or volume of water with relation to the aperture might be made a part of the investigation and appear in the result.

In such an attempt to find a general solution of the theorem it would at

once become evident, that there are two normal forms for the *vena contracta*, viz.: That, when the stream emerges *downwards* from an opening through horizontal edges, and that, where it emerges *upwards* through an opening of the same character. The first of these gives a pencil, whose shape for its longitudinal section at its upper end, or origin, will be controlled by the nature of the aperture, and by the effect of the initial directions of the particles of the effluent liquid (the theoretical *vena contracta, under pressure, but devoid of gravity*); modified by the effect of gravity, which would give to any descending pencil of a fluid, the motion of whose particles shall be established in approximately parallel lines, a hyperloid contour. The second of these will give a sheaf, whose shape at the point of efflux, will be determined by the same laws; while it would now be modified at this point, by the *load* of the emerging fountain, and at the same time the form of the stream above (in this case attaining on some plane an absolutely contracted section), would be that of a hyperboloid sheaf, with both *external* and *internal* lines of definition. If it be supposed in this second instance that the plane of efflux (of the orifice) is slightly deviated from the horizontal, so that the emerging stream is made to take a line out of the perpendicular one, the sheaf form would be disturbed; and at some quite small angle of deviation, a trajectory curve would take its place.

The general course of the stream would then have a modified parabolic curvature—a trajectory curve, which has been frequently discussed—but the exact contour of the pencil is still an open question. It is certain than when passing the point of greatest elevation, it would have, from its retarded motion, its greatest cross-section, and that this cross-section would be a flat oval of peculiar form; and it is probable that beyond this section, on the descending stream, it would become nodal, for the same reasons that a stream emerging from any orifice except a circular one becomes nodal.* In short the complete solution of the problem not only admits and assumes values for all the physical conditions, but it will embrace all directions of efflux from 0° to 180°, where 0° may be taken as the perpendicular direction, either upwards or downwards.

It is possible, for the purpose of illustration, to give some consideration of the *vena contracta* upon hypotheses similar to those of Professor Thomson, and if other conditions are assumed at the same time, an *appreciation* of the phenomenon can be had. In truth the view it is proposed to offer may go further than a mere appreciation, and may be made the basis for support of the other fundamental controlling conditions, and indicate the true line of procedure for mathematical investigation. Let us suppose, with Professor Thomson, that the effect of fluid friction, or viscosity, is neglected; that the magnitude of the vessel and the depth of liquid, is so large in relation to the dimensions of the orifice, that no appreciable velocity is imparted to the mass of liquid by the discharge; that the jet is one issuing downwards (so as to have the cross-section under absolutely uni-

*See article by Weisbach, "Ausfluss," In the "Allgemeine Maschinen Encyclopädie."

form pressure); that the orifice is a circular hole in a thin plate—the flat bottom plate of the vessel—and that the effect of gravity on the stream after emergence be neglected, as well as the atmospheric resistance and the acceleration due to the column of discharge, in the production of a vacuum upon the sectional area; and the following sketch (Fig. 4) gives a general ideal view of the *vena contracta* under these suppositions.

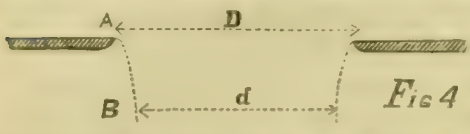


Fig 4

Weisbach* has observed that the actual diameter = d of the vein of emergence from a thin plate, is about 0.8 D; at the point B, which will be found from one-fourth to one-half the diameter (= D) from the plate; and this is accompanied with an efflux, as measured by the quantity of water discharged, of = 0.97v, where v = the velocity of flow = $\sqrt{2gh}$. Now it is an obvious conclusion that at any point on the surface of the *vena contracta* between A, the edges of the plate, and B, the point of minimum section, a particle of water must be in such equilibrium of pressure as to establish its direction of flow, or in other words its curved path; when it becomes apparent that some momentum must have been imparted to such a particle, to induce it to follow in its line of trajectory, instead of following the direction due to gravity, or to the application of the pressure normal to the head, or column of water above it. An attachment to the orifice can be constructed which will exhibit this phenomenon, or rather provide for its occurrence as a matter of necessity, as follows: Let there be an opening in a thin plate as before (Fig. 5), and let this opening be *guarded* or protected by a disc (Z) of the same diameter, = D, let this disc be placed so that its edges (C C) shall be one-eighth the diameter = $\frac{1}{8}$ D (C A) removed from the hole. On these suppositions, if the diameter of the section of least area, = d, be taken at 0.707 D, then the area of the peripheral opening (at C A) will be equal to the area on the plane of (B). The line of effluent stream (A B) may be imagined to be a quadrant of a circle, which will then have of course, a radius, = 0.147 D. Now let the face of

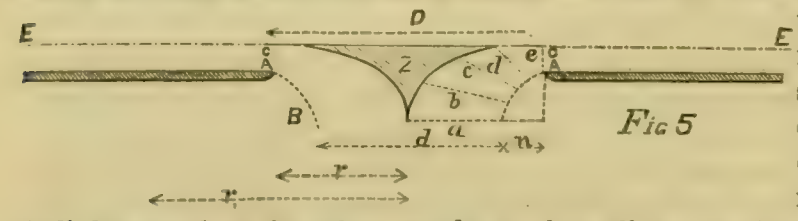


Fig 5

the disc Z be made a conoid, so that the areas of the surfaces of the conical frustra a b c d e shall be equal, or in other words, so that all the sections normal to the curve A B shall be equal.

[The co-ordinates for this curve of the face of the conoid Z, in terms of x and y, where x is supposed to have its origin at point of the prolongation of the line CA on the line B; are given by the equation:

$$y = \frac{\sqrt{[r^2 + n^2 \pm \sqrt{(r^2 + n^2)^2 - 4n^2x(2r - x)}] - 4(r-x)^2(r+x)^2}}{2(2r - x)}$$

*Weisbach's Mechanics.

In this equation r = the radius of the opening commencing at the origin of x, and n = the radius of the quadrant or corner commencing at the same point.

The assumption of the quadrant of a circle for the path of the effluent particle from A to B, has been made in order to give a simple equation for, and ready comprehension of, the nature of the sections of the stream normal to its face on A B where, by equalities of areas, uniform velocities would subsist; but the real curvature (A B) is obviously parabolic, and the plane of B is infinitely distant from (below) the plane of A. Observation has shown, that at about one-fourth D below the plane of A the least section of *vena contracta* is apparently reached, and that below this plane of section, the pencil of descending current has its sides with only so much divergence from parallelism, as is due, almost entirely, to the acceleration of the falling stream. An elliptical quadrant which shall approximate to the true parabolic curve can be readily substituted by construction (or calculation) for the quadrant of a circle, in the equation above quoted, and the new values for y, will give loci for the curve of the face of the conoid Z to correspond to the substitution. The value of the radius of the minor axis on the line B as determined by observation, may be taken as that of (n) in the equation. By this method a very close approximation towards the true form may be attained.]

It will then result that the efflux from the peripheral opening C A inwards, having any given velocity, will, in every part of the current, until the least section of the *vena contracta* on the plane B is reached have a uniform and constant rate of speed; neither acceleration, nor transformation of head into velocity, will have occurred in the change of direction. If the consideration of the fluid friction, etc., be not taken into the question, and the velocity of efflux at C A is that due to the head, that at B is established and maintained; whence any liquid particle on the surface A B must be in equilibrium of pressure, both from head or momentum in direction of its flow, *in which direction the entire head is transformed into velocity.* The plate, or plane surface of D, may be imagined to extend indefinitely in the directions, E E, in which case the velocity of flow of liquid, interposed between the plate E and the bottom A, will decrease as the radial distances from the edge of the aperture; in inverse ratios of the radius r to any new radii $r_/ r_{//} r_{///}$: while the height, of liquid column corresponding to the several velocities, = V at r, $V_/$, at $r_/$, will vary as $\left[\frac{r}{r}\right]^2 : \left[\frac{r}{r_/}\right]^2 : \left[\frac{r}{r_{//}}\right]^2$ &c. The pressure or total height is supposed to have been completely transformed into velocity, = V, at the peripheral opening C A, and the stream or sheet of fluid would exert no transverse pressure at C A, either upwards or downwards; while the transverse fluid pressure on the supposed plate or the bottom of the vessel would vary as $\left[\frac{r}{r}\right]^2$ (at C A) to $\left[\left[\frac{r}{r}\right]^2 - \left[\frac{r}{r_n}\right]^2\right]$; r_n being any assumed radial distance from the centre of the opening. Thus if the radius r be taken as

one-half inch, and that of r_{11} as five inches (or ten times r), the velocity of flow towards the aperture at r_{10} would be only one tenth of that at r; the head required to produce the velocity at r_{10} would only be one-one-hundredth of that corresponding to the velocity at r; and the pressure of the head remaining on the plate or bottom at r_{10}, would be ninety-nine-one-hundredths of the total head.

These two pressures on the plate and the bottom would be equal and opposite pressures, and if the plate were removed, the unbalanced pressure on the bottom would represent the force P, to which Professor Thomson gives an undefined value. Its total, is of course the sum of the head upon the area of half the opening, and continuing the supposition of removal of the plate, it is encountered and balanced by the *momentum of the descending mass*, so that the bottom would now be in equilibrium of pressure, and the force P, as an unbalanced one, would disappear.

Returning to the examination of the proposition as shown in Fig. 5: the static resistance of the under surface of the conoid Z in a vertical direction against the flow of water in its radial movement towards the centre of the orifice, and while following the path of the under surface of the conoid, is represented in total by the divergence at right angles of the entire effluent stream; = to $\frac{1}{2}$ D of superfice, under the head which has produced the efflux. The reaction of the flow of liquid downwards is also equal to another statical resistance of the same value, and in the same direction; and as the total pressure on the conoid Z from above, is its entire upper surface, under the head of liquid above it; the one pressure above balances the two pressures below, and the conoid itself is in equilibrium.

If it is now assumed that there exists no frictional adhesion of the liquid to the surfaces of the supposed plate, and of the bottom of the vessel, and the vessel is of indefinite extent, so that the velocity of entry at E E is reduced to an inappreciable rate of flow, then the condition of the formation of a perfect *vena contracta* will have been exhibited. The removal of the guide plate E E, and the removal of the bottom of the vessel, and substitution of a re-entrant tube, would replace the supposed frictionless surfaces by liquid mass, which if it is still continued to be supposed devoid of *viscosity*, would enter the peripheral surface C A with the same force, and in the same direction, and would still preserve the same perfect *vena contracta*. The removal of the conoid Z would provide a fluid conoid of the same shape, *or a distribution of internal strains* productive of the same resistance, and (still assuming the perfect liquid) the same perfect *vena contracta* would follow. If however there is admitted to exist a certain adhesion to the bottom of the vessel, or to the surface or edges A A so that the velocity of a particle on A B is less than that fully due to the head; the surface (d) would then become larger than $\frac{1}{2}$ D, the dimension C A would be properly increased to give the corresponding area of efflux, and the conoid Z would also have such a contour as would permit the uniformity of flow of each and every particle of the liquid at unchanged velocity, in any section of the *vena contracta* transverse to the direction of the flow. This increase

of dimension of the cross section d, and the effect of the descending pencil in accelerating the flow through it, can be taken as sufficient to account for Weisbach's observed value of $= 0.8D$, and position of least section at $= \frac{1}{4}$ D, as has been before quoted.

It must not be taken for granted that the writer is arguing that the conoid Z actually exists in the water, but it is here assumed for the purpose of showing that all the phenomena of the *vena contracta* are consistent with the supposition. Mr. Froude's "*tangential*" direction for the fluid in Fig. 2, which he says appears if closely studied, is a portion of the proposition, and this discussion exhibits "the imparting of velocity and *vis viva* outside of the plane of the orifice," as alluded to by Mr. Napier

There is one other point worthy of notice in this radial flow of currents towards an orifice, and the radial direction at the edges of the opening. With or without the assumed central, neutral conoid, this flow is in exceedingly unstable equilibrium, especially when in contact with a bottom plate, (the friction or adhesion to which retards the flow), the radial direction may be diverted to a small extent, so that the particle of water where it curves at the point A, or at any other point on the line C A may possess absolute momentum out of the line towards the central axis of the pencil.

The radius of the opening calls for a very slight deviation of entering horizontal current, when its dimension is compared to the area from which this current is derived ; and there is really but the slightest cause for the currents to direct themselves to the exact centre of the orifice. In point of fact the permanency of the *vena contracta* of downward discharge is derived in great degree from the pressure of the atmosphere, which is brought into action, by the descending pencil below it. The effect of a tangential afflux at the peripheral circle C A is to give a rotation to the pencil, which at once accelerates, to some limit of discharge, and obliterates the *vena contracta* The motion of the particles will yet remain limited *in any direction* by the head, but as the stream emerges with a rotary motion, the path of any particle becomes a spiral one, and the whole pencil advances, or is discharged, at a slower rate than is due to the particle velocity. In the case of the re-entrant tube, where the pencil is divested from the effect of gravity, by exhaustion of the air by the effluent stream passing from the tube, it is very difficult to get a *vena contracta*, as Mr. Froude testifies. This action of the tangential afflux is not confined to the emerging stream, but shows itself in the vessel as well, where a whirl is established which involves the entire mass of water enclosed. In the case where the bottom of the vessel has a funnel shape, this whirl sets up with great vehemence, and the centrifugal force of the established current may be sufficient, under favorable circumstances of form, head and dimension of vessel, to displace the entire central portion of the liquid, and the pencil of emergence will become a tube, whose core will be filled by an induced current of air. These phenomena of efflux are only noticed to embrace in my remarks some of the influences which effect the *vena contracta* where the conditions of formation are varied by adjutages, and to make it evi-

dent that neither the study of phenomenal nor the mathematical considerations involved, have been exhausted in the papers of the Glasgow Philosophical Society, while the present article does not pretend to do more than to indicate the direction in which enquiry should be pursued.

Remarks upon the Tónkawa Language.

By Alb. S. Gatschet.

(*Read before the American Philosophical Society, Nov.* 17, 1876.)

A small body of Texas Indians, the wretched remains of a once powerful tribe, bears the name of *Tónkawas* or *Tónkaways*, and is called *Tónkahuas* by Spanish writers. Through the unfortunate homophony of their name, they were frequently confounded with the Central Texan or coast tribe of the Towakonays, who certainly were congeners of the Wichitas and Wacoes, and led a nomadic life in close community with the Karankáhuas, Arrenámus and Caris. A bay in the middle part of the Texan Gulf Coast is called Carancáhua Bay up to this day. At the time when Spanish missionaries, along with a number of their Aztec helpmates, had colonized the South of Texas, and disseminated the germs of the Roman Catholic faith among the untutored tribes of aborigines, whom they induced to join in agricultural pursuits in the vicinity of their missions, the Indians were treated with humanity. Then Mexico and all Spanish America freed itself from the domination of the distant mother country; Texas declared itself independent from Mexico, and when after another lapse of time the Texan settlers proclaimed their adhesion to the American Union, a war of extermination commenced against the helpless Indians, which up to our days continues without abatement on the northern border against the roving bands of the Lipans, Comanches and Kiowas.

The Tonkawa tribe, however, whose first mention in American annals occurs at the commencement of this century, seems to have suffered more from internecine wars and feuds with the Comanches, than from white settlers. In 1847 official documents put down the number of their warriors at 155, a decrease of about two-thirds since 1820. The remnants of the tribe, about 35 warriors with their families, are with a number of Lipan-Apaches at present gathered on a reservation in Shackleford County, Northern Texas, seven miles from Fort Griffin. They raise stock, hunt the buffalo, and serve as scouts on the expeditions of the United States troops stationed at Fort Griffin. They are exceedingly filthy in dress and habits, paint their faces in a grotesque manner, and live in canvas tents. Their national legend represents them to be the offspring of the *wolf;* hence this animal is worshipped in their *wolf-dance*, of which Schoolcraft has given a description (in Vol. V).

Two Bavarian gentlemen have lately visited and studied this obscure and half-forgotten tribe, and have favored me with their notations on the na-

tional idiom. One of them, the chemist Oscar Loew, visited in August 1872 that section by order of the "Texas Coal and Copper Mining Association" for metallurgical and mining purposes, and in subsequent years became a very efficient member of Lieut. Geo. M. Wheeler's Surveying Expeditions west of the 100. Meridian. His field-notes on Texas and the Tonkawas have been published in "Petermann's Mittheilungen," Gotha, 1873 (December). The linguistic materials collected by him and Mr. Fr. von Rupprecht were published in full by me in my recent book:

"*Zwölf Sprachen aus dem Südwesten Nordamerikas, Weimar* 1876;" and this article here merely contains the results of a closer investigation, hitherto unpublished, of the Tonkawa words and sentences transmitted to me.

Tonkawa differs absolutely in its radicals from all surrounding American tongues, and the few terms coinciding seem to have been *borrowed* from neighboring idioms. Most syllables *begin and terminate* with consonants, but consonants never preponderate in number so as to obscure the pronunciation of the vocalic elements. The consonants composing T. words are as follows:

Explosives: k, g; t, d; p, b; x; tch.
Spirants: s, sh, h, v, y (in English: *yoke*).
Liquids: n, m, l, r.
f does not occur; d and r are scarce, and g very unfrequent.

Among the vowels i, e, a, o, u (all sounds were given here the *Italian* pronunciation), *a* alone is softened into the "Umlaut" ä (ekkvan and ekkvän *dog*) and forms the diphthongs ai and au. No other diphthongs exist but eu, ei, oi; and those formed with y (ya, ye, yo, yu), if we choose to call them diphthongs. As in most of the Northern idioms of America, vowels frequently form a hiatus: e-e-ion *week*, esamó-i *broom-weed*. Combinations of three consonants frequently occur, but they never sound unharmoniously to our ear, and in fact the Tonkawas seem to be endowed with a remarkable sense for linguistic euphony. They lack the softer palatal dsh, and all the aspirates but χ (or kh): the hard guttural occurring in Welsh, in German ("trachten") and in Spanish (j in *mujer*, *dejar*); -s at the end of words generally becomes -sh or -tch, and it alternates throughout with sh. A final -n is exceedingly frequent. The mutes often alternate among each other, b with p, g with h, k and χ (and t with tch).

Redoubling the monosyllabic root is a means of grammatical synthesis extensively used for *various* purposes by all languages known; the T., however, seems to employ it almost only for onomatopoetic purposes, as in: tchatchaya *to laugh*, koχoχua *to breathe, perspire*, tchutchuɣ *to be scared*. The nature of the material available does not as yet allow to establish general grammatical laws for the T., but permits a glimpse at its method of compounding words, and gives a few indications of structural import. The system of the object and subject pronouns seems to be rather intricate.

The negative particle *not* consists of two parts, *ka* and *pa*, which are frequently placed one aside of the other, as in Apache, and in Tehua (New-

Mexico). But more frequently only one part of it appears as k', ka, g'; b', ba, p', pe—as in: tcheno *to be*, tchapeno *not to be;* ne-enoɣ *to know* (?), nek-enoɣ *to ignore*, gin'ɣenu *I do not know* (g is here the negative particle); shai *ka* tu lel *I have no time;* shaya yétsoɣanak on *be: I was not in the house.* Where it can be done, the negative particle is incorporated into the stem of the verb as *ba* or *bó:* hé-el yaɣa *he eats*, hé-el yaɣaƅó *he does not eat*, χaχaha *I was* or *went*, χaɣabaha *I was not* or *did not go*. *No!* as a negative answer to an inquiry is *aga*, (*a-ka*)!

Kapa, the two particles combined, or *kapai*, *kapa-i*, evidently has the force of an adjective: "none, nothing": shai aɣ kapa yeshik *I have* NO *water;* shai aɣuenɣa kapa yévuesh *I have no horse.* It is also pronounced *kopei*, *kopeia*, and in this form occurs as a privative particle in compounds: shenɣōn *dress, coat:* sankuon-kopei *naked*, kopeia-veika *poor, indigent* (the root of veika lies in yé-vuesh *to be possessed of*).

The first syllable of the word (ka-,ko-) probably occurs also in a protracted form in ka-a *sick.*

PREFIXES.

A number of *prefixes* can easily be pointed out in T. verbs and nouns, but to find out the real power and original meaning of these prefixed syllables is a difficult task. *He-* is a frequent prefix in nouns and verbs, and is found also in interrogative pronouns and particles as well as in the demonstrative pronoun of the third person singular; hé-el, helatla, *he, himself.*

he-yatchon *eyeglass,* cf. atche *to see.*

he-lepuen *tree, forest.*

he-ntaitchon *tooth.*

he-nshon *blood* cf. ya-tson *heart.*

ha-lonkaiχaχ *knife,* cf. ya-lona *to kill.*

ha-wei, ha-vei *large, big, high, tall.*

he-ktau-e *to sing, chant.*

ha-iχo *to ride on horseback.*

The prefix *ne-* occurs quite often and is used in forming verbs from nouns and nouns from nouns or verbs, as can be inferred from the following examples:

ne-baɣka *to smoke,* from baχka, the English word *tobacco.*

ne-shuana *to shoot,* and ne-svon- in the compound nesvon-pillel *round of ammunition.*

ne-vauva *to expire, die.*

ne-k-enoχ *to ignore* (lit. "not-well [know]").

ne-muetan *eye* (root probably in metan *to flash up*).

ni-muetchχon *nose,* derived from the preceding.

ni-kamon *bone.*

ni-steχon *ice,* from teχon *rock, stone.*

ne-shgashan-oyuk *towel.*

The most frequent of all the T. prefixes is undoubtedly *ya-*, *ye-*, *yo-*, found in verbs as well as in nouns. In active verbs it seems to fulfill the functions of an object-particle incorporated into the verb, as we see it occur-

ring in many Mexican, Southern and Northern languages; in Aztec f.i. the particles *te-, tla-, tetla-*, are used for this purpose. The nature of this particle is elucidated by the following grammatical juxtapositions :

kala *mouth :* ya-χa *to eat.*

shaya *tchen* vantch *I see thee :* naya ki *ye-tchu thou seest me.*

veika *possessed-of, having* (in : kopeia-veika *indigent*) : shai yé-vuesh *I possess* (aχuenχa *a horse*) : auvash ye-yaχanosh *I eat buffalo-meat* (here the particle occurs twice).

In these sentences the particle *ye-*, connected throughout with transitive verbs, has a reference to the direct object, which either precedes or follows the verb. It is found to occur also in the following transitive verbs : ya-lona *to kill*, yo-χoya *to hunt*, perhaps also in eisatuk *to cut, sever*, if this term is misspelt for ye-satuk.

Some of the following substantive nouns built up with this particle can be distinctly traced to their respective radicals :

yé-tsoχan *house*, originally *tent*, from tsoχ *cloth.*

ye-tsoχe i-tsan *button*, from tsoχ *cloth.*

e-shauké-huen *shirt* (probably instead of ye-tsoké-huen, from tsoχ *cloth*).

ya-χau *spur*, from χaχa *to go* (or to make go?).

ye-koχon *boot*, from kaχa, χaχa *to go.*

ye-kevân *entrails, guts*, from kevano *wet.*

ya-teχon *stone, rock*, cf. helepuen-teχek *"mountain-forest."*

ye-ntan *wind.*

yo-tchan *nail* (on fingers and toes).

ya-tson *heart.*

ye-la *chair, seat.*

e-baχu-eta *womân* (instead of ye-baχu-eta?).

ya-tch-χenon *bread*, from yá-χa *to eat.*

The word for *stone, rock* seems to have two forms : *teχon*, and *ya-teχon*, and the circumstance, that this prefix *ya-,ye* - is generally found in substantives along with the affix *-an, -on, -en*, etc., proves that there exists some connection between the two. Evidently they are the two principal elements used in building up substantives from the monosyllabic roots.

There are many reasons for assuming that *s-, sh-* is a Tonkawa prefix, though it cannot yet be distinctly proved to be such. It occurs in the following pronouns, nouns and verbs :

shaya, shai *I, myself.*

hetet-shá *whereto?*

hetet-sho-olok *what thing?*

shapon *to hide, conceal.*

shoyana to *swim*, cf. esvalan *fish*, aye *to move*, or *live in water.*

soskuono *to hear* cf. χaion (in :-enatch-χaion *ear*).

si , se- is also prefixed to the numerals 4, 6, 7, 8, 9, 10.

A few terms of Loew's vocabulary begin with the syllable *ok-*, which I presume to be rather a generic term than a prefix. Perhaps it means "animal" or "quadruped," for it occurs in okau *skin, fur-skin*, okemeillo

hog, swine, okmek *lion,* and probably stands also in the initial syllable of okopák-ɣōn *hat* (originally made of skins or fur), in: aɣuenɣa *horse,* and *ukuen dog,* which is spelt ekkvan by Mr. von Rupprecht. We have here another instance of the curious fact that the horse and the dog are called by Indians with the same root or word-stem and we would possess many more of these instances, if the horse was not so frequently called by the imported Spanish term kaway, kaváyo. The following table gives an enumeration of the terms for *horse* and for *dog* from various tongues:

Isleta (New Mexico)	ganidá, *horse*	kuyanidá, *dog.*
Natchez	wvskupser	wvskup (v = a short surd ă.)
Yuma-Tonto (Arizona)	χata	tsata.
Dakota	shunktánka	shúnka.
Payute	pung-gú	pung-gúts.
Sahaptin	kússi	kússikussi.
Wintoon (California)	shuku	kanti-shuku.
Klamath	uátch	uatchága

The last-named term *uátch* simply means "living creature, being," and *uatchága* is its diminutive, from *uá to exist, to live, to stay;* applied to our Tonkawa terms composed with *ok-*, this supports the opinion, that *ok* and its compounds have a similar signification of *creature,* or animated *being.*

The Natchez term for *horse* is the augmentative of wăskup *dog,* and as Dr. D. G. Brinton has shown, *wăs* is "apparently a generic term for a certain class of animals," and occurs as *wĕ* in the language of the Uchees or Yuches, which forms a similar series of compounds.

Okemeillo *hog, swine* is really the "beast feeding on the meadow," for hueu-meil means *prairie* or *meadow.*

AFFIXES.

Of a more diversified character than the formative prefixes are the *formative affixes,* that is the syllables *appended* to roots or word-stems, and intended to form derivatives.

We frequently meet f.i. a terminal syllable -i in nouns, which is appended almost only to vowels and often coalesces with them into a diphthong:

shaχe-i *shadow, shade.*	aχaloi *ant.*
esamo-i *broomweed.*	kapai *nothing.*
také-i *head.*	tei-i *liver.*
tsélai *cloud.*	senanda-χas-i *copperhead snake.*

A second derivational affix *-eta* occurs in the words:

nemuetan *eye.*

beχueta, ebaχueta *woman.*

keta-, kete- *friend, partner* (in: ketepanon *my partner*).

Compare this affix with eta *to come* and with the particle hetetá? *where?*

A third affix in *-k* (-ak, -ek, -ik, -ok) frequently turns up in substantives, adjectives, and other parts of speech:

kalok *beard, mustache,* from kala *mouth.*

tsatsχok *piece, slice* (f.i. of meat).
χak *hair* (on head).
galak *more.*
hitanok *soon, in a short time.*
malek, in : nemuétan malek *eyelid.*
ok-mek *lion.*
oyuk *sack, pocket, bag,* cf. toyo *to put into.*
namek *dry wood.*
makik *yellow* 2) *gold.*
masslok *white;* 2) *cattle.*

This -k affix seems to indicate a spot or place and may be equivalent sometimes with "*on him, on it, on this.*" See the locative case below.

The existence of a fourth affix *-la, -lan, -lo* (o frequently alternates with a, both being probably surd ă), occurring as yet in substantive nouns only, may be inferred from the following words :

anip-'hei-la, enopχa-lo *moskito.*
apinki-llin *fly* of various colors, red, etc.
esva-lan *fish,* enko-ó-la *bird.*
haku-läno *valley* "where *water* is," cf. aχ *water.*
ka-la *mouth,* from ya-χa *to eat.*
kva-lo *stick,* in ne-χo-o-kvalo *gun, rifle* from kue, kve *wood.*
χa-lan *fever and ague,* from ka-a *sick.*
χa-lo *tumbler, drinking-glass,* from χane *to drink.*
masloχ-é-lan *snow,* from masslok *white.*
naχtchon-se-lon *fire-match,* from naχtchon *fire.*
tcho-ó-lan *excrements.*

-la is found also in the personal pronoun helat-la *he, himself,* but this is most likely the particle *ala,* which occurs in many other pronouns and is here apocopated, as the possessive élatan (*his, hers,* or *its*) demonstrates.

In the numeral series, this particle *ala* is used to form the decades or tens and may be rendered by "*times*":

sikbaχ *ten.*
sikbaχ ala kita *twenty,* (10 times 2).
sikbaχ ala mitish *thirty,* etc.

In spite of the small number of Tonkawa verbs, of which we are cognizant, some formative endings constantly recur, and we are therefore justified to consider them as derivational affixes forming verbs. One of them is *-aua, -ua:*

atsoχaua *to cool down,* from atsoχ *cool.*
hektaue *to sing.*
koχoχua *to breathe,* keshkua *to be fond of.*

Another, the sixth of our series, is *-ana, -ano, -ono* etc., which we discover in the following verbs:

shoyana *to swim.*
metan (instead of metana?) *to flash up* (said of lightning).
ne-shuano *to shoot.*

ke-vano *to be wet; wet, wetted.*
ke-ei$_{\text{L}}$ena *to be hungry; hungry, famished.*
χane *to drink* (same root as yaχa *to eat*).
shapon (instead of shapona ?) *to hide, to conceal.*
yalona *to kill.*
soskuono *to hear.*

This affix is evidently identical with the verb *eno, enu, tcheno,* which is rendered by *to be, to exist,* but whose primitive signification is that of *going* or *coming* (ena, aina).

Further verbal formatives can be traced in: *-aya, -oya:*
tchatchaya *to laugh,* yoχoya *to hunt,* toyo *to put into.*
in: *-na, -no:*
shokna *to put into,* tchoχno *to sleep.*

This ending probably originated through the syncope of verbs in *-ana, -ona, -ono* etc.

The most important affix and the ninth in our series is found in all the different categories of nouns (to the exclusion of verbs, probably). This is the affix *-n,* and its occurrence in participles of the active form of verbs seems to give the key to its real meaning. We have, f. i.:
tchoχnon *physician,* from tchoχno *to sleep, to lie in bed.*
atsoχauan *north wind,* from atsoχaua *to cool down.*

In the derivatives quoted hereafter this ending evidently has *different* functions to fulfill:
he-yatchon *eye glass,* from atche *to see.*
ayon *foot* (from aye *to move?*).
ye-koχon *boot,* from kaχa *to go.*
ye-tsoχan *house, tent,* from tsoχ *cloth, canvas.*
Kānoshan *Mexican,* from Kānosh *Mexico.*
táχshon *morning,* from tagash *sun.*

But the terminals *-an, -en, -in, -on, -un* appear also in a considerable number of nouns, whose roots, stems or their meaning are yet a mystery to us (*-kin, -χin* forms possessive pronouns), and of which we give here a short aperçu:

Adjectives:	χaton (also: χatana) *green.*	
	taχon *warm, hot.*	
Substantives:	etchnan *day.*	tan *tail.*
	nitχutan *paper.*	helepuen *forest, tree.*
	hepeian *beads.*	bopaχon *fox.*
	ya-tsoχgan *table-fork.*	tróniχon *grass,* etc.
	natun *hill, mountain.*	

Curiously enough, *-en* also stands at the end of the higher cardinal numbers, from fifteen upwards:
koskua *five,* koskua-en *fifteen,* sikbaχ-ala-kita kita-en *twenty-two.*

Tree or *wood* is kve, kue and the *shadow of a tree* is shaχe-i kauvan; hepeian is *beads,* and taχuaz-loman-hepaian is *neck-cloth, neck-kerchief.* From this we may conclude that *-n* in *kauvan* is the sign of an oblique

case, the *possessive*, and that hepaian simply means "on the neck," or "belonging to the neck," or "of the neck;" then hepai, hepei, or hepaia would be the term for *neck*.

Cases. By a similar analytical process we arrive at the discovery of a few other case-suffixes. Putting together the sentences in which the endings *-ak* and *-ok* are found, we get the following:

shaya yetsoχanak enubaha *I am not in the house.*

shaya yetsoχanak on be *I was not in the house.*

hetsho-olok yaɻanoka? *What do you eat? What do you feed on?*

χananoke vauva *to die of poison.*

The two first sentences give us a *locative* case in *-ak*, the two latter an *instrumental* case in *-ok*.

The vowel *-u-* occurs at several places, where it seems to be a case-suffix, but is not yet demonstrable as such. If aχuelpa, for instance, which means *source, spring-water*, is composed of aχ *water* and he-lepuen *thicket, wood, tree*, (springs are often found near thickets), the inserted *-u-* can hardly be anything else but a case-suffix or a particle of relation; secondly: etatχono *to speak* is composed of eta *to come* and χon *a man, man* and therefore signifies in fact "*to come to a man.*" From this may be inferred, that *-t-* and *-o-* (*-u-*) are both particles of relation.

The ending *-sh*, which in verbs is used as a substitute for the pronouns shaya *I* and shaibaɣ *we*, does not seem to be used as a case-suffix, but is found sometimes incorporated in the midst of words, as in naɻtchon-se-lon *fire-match*, ya-tch-χenon *bread* (*ya-* prefix, yaɣa *to eat*). As a final sound we find it in words like:

tagash *sun*, from taɻon *warm, hot* (cf. Aztec tonatiuh *sun*, from tona *to be hot*).

nashish *terrapin.*
auvash *buffalo* cf. au *deer.*
apinshos *common fly, house-fly.*
mitish *three.*
se-ketiesh *eight.*
mish- in : mishbaɣ *one.*
nosóss *young.*
há-ash *many.* (See : prefix *sh-*.)

Having discussed the more important features of T. grammar in my German publication, I shall not at present dwell any longer upon this subject, but pass over to the etymological dissection of some compound words and wind up with some ethnographical remarks of general interest.

In forming compounds of two substantives, the Tonkawa language places the depending *after* the governing substantive. *Man, male* means a-akon, in compounds akon; it occupies the first place in akon-kválo, the man of the staff or stick, viz.: *the chief;* it stands second in such terms, as designate objects for personal use, instruments, etc., f.i. okopák-χōn *hat* (lit. hat of man). Adjectives not used as predicates seem bound to stand behind the substantive or noun they qualify: aɣ iχ *bad water*, akon vóɣvan *little, young man, boy.*

From *atche to see* I derive the following terms: etchnan *day;* daylight, shining and seeing being ideas closely connected among themselves; tagash-aitchótak *the east*, lit.: "*sun-where-to see,*" the direction in which

we first see the sun; he-yatchon *eye glass.* If na-ashod *moon* is a term formed after the "*aitchótak*" above, equivalent to "rising," "going-up" (na-aitchót?) and to the Klamath word ka-ukó'ĕsh *moon* (lit. "*the ascending one*"), it must also be derived from atche *to see.*

kue, tree, wood, stick, gave origin to the following T. words: akon-kvalo "the man of the stick," *the chieftain;* tsoχnetch-le-kvan *soap,* viz., "*stick* to wash cloth (tsoχ) with;" nitχutan-kve *lead-pencil,* viz., "paper-stick;" neχoo-kvalo *rifle, gun,* viz., "shooting-stick," probably misspelt for nesho-o-kvalo, ne-shuano meaning *to shoot.* Ekvuahen *horn* is probably derived from the same word, as horns frequently bear some resemblance to pieces of wood (instead of e-kvua-en?), and the numeral *six,* si-kualo, recalls the word kvalo, which is reduplicated in *nine,* se-kueskuelo.

teχon rock, stone reappears in ya-teχon *rock,* ni-s-teχon *ice* (water-stone!) and in helepuen-teχek *forest, thicket,* literally: wood of the hill. This refers to the circumstance that in the southwest forests are found on elevations only, while the plains remain bare of any woods.

atch earth, land turns up in etcho-χanásh *prairie-dog,* the well-known burrowing rodent of the west, Spermophilus ludovicianus, forming extensive underground colonies.

tsoχ cloth, canvas is the etymon of many terms mentioned above, and of: ye-tsoχe-i-tsan *button,* tchoχ-tchapol *blanket,* tsauχ-yetsuχan "*canvas-house,*" *tent;* apparently also of: niese-tsoχ-kanov *dry, dried,* meaning perhaps a *cloth* (tsoχ) *dried* by the wind or the fire. Not knowing the original signification of tsoχ, we cannot decide if tchóχno *to sleep, to lie in bed* is derived from it or not.

a-atchoke rich is derived from ha-ash *much, many,* initial *h-* being deciduous in many of the Indian languages.

au deer, auvash *buffalo,* okau *fur-skin,* nauval *robe, animal-skin* are all derived from the same root *au.*

yentan, yandan wind forms yentan-auvei *the south,* lit. south-wind. Auvei, hauei is *strong* and the "*strong-wind*" is the breeze blowing with impetuosity from the coast of the Gulf of Mexico.

keta friend, partner, is identical with the numeral *kita two* and simply means "we two," or "two of us." From kita *two* are formed the numerals si-kuit *four* and se-ketiesh *eight.*

Conclusion.

The confutation of errors, whether they be of importance or not, is always attended with good results, and if we can profit in science and knowledge by such confutation, we should not lose the opportunity. It will not take long to prove with linguistic reasons, that the supposed affinity of the Tonkawas with the Caddoes does not exist.

Words and syllables in Caddo end almost *exclusively in vowels;* words of one syllable are scarce, almost every word has two or more syllables and in dissyllabic words the accent rests on the penultima. Diphthongs occur, but are often recognized with difficulty, owing to the queer method of

transcribing the language; groupings of consonants rarely occur, in T. frequently. *One simple consonant* generally heads the word and syllable; names for colors begin with *a-* or *os-*. The parts of the human frame mostly terminate in *-to, -co, -no, -son;* others begin with *oko-, okun-*, which would not be altogether disparate from the T. akon *man*, provided it has the same signification. It is true that the Caddo: nishe *moon*, aχkóto *cold, winter* bear some external analogy with the T. na-ashod *moon* and atsoχ *cool*, but there is often a wide difference between resemblance and real affinity. I have given elsewhere a collection of T. words resembling to terms of the surrounding idioms, which might be augmented indefinitely. Only one of the compared languages has yielded a few terms resting probably on real identity, and that is *Aztec*. We find T. (ya-) χa *to eat*, ka (-la) *mouth* and Aztec (tla-) ka, ka (-matl); T. hauei, auvei *great, large*, Azt. vei, huei; T. aχ *water* and Azt. atl. If these coincidences, which Tonkawa has in common with many Sonora languages, are increased by others, we may look out for proofs of old connections between the two ethnical bodies; connections through commerce, expeditions, emigrations or immigrations, not as yet through ethnological affinity. Up to this day a kinship of the Tonkawas with any other American nation or tribe has not been shown, and neither Aztecs, nor Shoshones or Caddoes can claim it on linguistic grounds. A faint resemblance could be traced in two Caddo terms only and phonology as well as grammar disagrees in most particulars from that of the Tonkawas.

NOTE.—Remember well, that the χ used here has *nothing to do* with the English *x*, but represents the harsh, guttural aspirate *kh* unknown to the English language.

On the Atmospheres of the Sun and Planets.

BY DAVID TROWBRIDGE, A. M.

Read before the American Philosophical Society, November 3, 1876.

There are two cases to be considered; in the first place we may suppose the body surrounded with an atmosphere, to be so hot as to influence, to a considerable extent, the density of the circumambient fluid; and in the second place we may regard the planet as cold like the earth, and as we suppose, Mercury, Venus, and Mars. I shall suppose the atmospheres composed of gases which are subject to the same laws as terrestrial gases.

1. Let us suppose the solar or planetary body to be a sphere of radius r. Also let z be the hight of any stratum of the atmosphere above the surface of the planet; ρ the density of that stratum; Z the force of gravity at the hight z; g the force of gravity at the surface of the planet; $\triangle$ the density of the atmosphere at the surface of the planet; p the pressure at the hight z; P at the surface; t_0 the temperature above 32° Fah. at the surface, and t at the hight z; λ the coëfficient of expansion; or the fraction expressing

the increase in volume for an increase in temperature of 1° Fah., so that if V_0 be any volume at the temperature of 32°, it will become $V_0 (1 + \lambda t_0) = V_1$ at the temperature t_0 above 32°; and at the temperature t above 32° the volume will be

$$V_0 (1 + \lambda t) = V_1 \left(\frac{1 + \lambda t}{1 + \lambda t_0}\right) = V \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

Since the pressure is equal to the weight, we have

$$dp = \rho Z \left(\frac{1 + \lambda t}{1 + \lambda t_0}\right) dV_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

This equation applies for the hight z. We have

$$V_1 = \tfrac{4}{3} \pi [(r + z)^3 - r^3], \text{ and } dV_1 = 4 \pi (r + z)^2 dz \ldots\ldots\ldots (3).$$

$$Z = \frac{gr^2}{(r + z)^2} \quad (4), \qquad t = \frac{r^2 t_0}{(r + z)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Mariotte's Law gives

$$p = \frac{P}{\triangle} \rho, \qquad dp = \frac{P}{\triangle} d\rho \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6).$$

If we substitute these values in (2), and make the second member negative, since ρ decreases as z increases, we shall have

$$\frac{1}{\rho} d\rho = - 4 \pi gr^2 \frac{\triangle}{P(1+\lambda t_0)} \left[1 + \frac{r^2 t_0}{(r + z)^2}\right] dz \ldots\ldots\ldots\ldots\ldots (7).$$

The integral of this gives

$$\text{Log. } \rho + C = - 4 \pi gr^2 \frac{\triangle}{P(1+\lambda t_0)} \left[z - \frac{r^2 \lambda t_0}{r + z}\right]$$

When $z = 0$, $\rho = \triangle$, and $C + \log. \triangle = 4 \pi gr^2 \cdot \frac{r \lambda t_0}{P(1+\lambda t_0)}$, and

$$\text{Log. } \frac{\rho}{\triangle} = - 4 \pi gr^2 \cdot \frac{\triangle}{P(1+\lambda t_0)} \left[z + \lambda r t_0 - \frac{r^2 \lambda t_0}{r+r}\right], \text{ or}$$

$$\text{Log. } \frac{\rho}{\triangle} = - 4 \pi gr^2 \cdot \frac{z}{P(1+\lambda t_0)} \left[1 + \frac{r \lambda t_0}{r+z}\right] \ldots\ldots\ldots (8).$$

Now make

$$\frac{4 \pi gr^2}{P} = \frac{1}{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9);$$

then we have

$$R \log. \frac{P}{\triangle} = - \frac{z}{1 + \lambda t_0} \left[1 + \frac{r \lambda t_0}{r + z}\right] \ldots\ldots\ldots\ldots\ldots (10).$$

Let us take the surface of the earth as the unit of surface, the radius of the earth as a linear unit, and the force of gravity at the earth's surface as the unit of gravity.

2. Let D′ be the density of mercury at the temperature of 32°, and D″ its density at t_0 above 32°; then, if λ' be the coëfficient of expansion for a volume of mercury,

$$D' = (1 + \lambda' t_0) D'' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11).$$

Let h′ be the hight of a column of mercury on the unit of surface, and at the temperature of 32°, that will just balance a column of atmosphere

on the same surface, h'' the hight of a column of mercury on the unit of surface on a planet, at the temperature t_0 above 32°; then the mass of the first column will be $4\pi h'D'$ very nearly since h' is about 30 inches, and the weight will also be $4\pi h'D'$, and this will be equal to P_0 the pressure on the unit of surface on the earth. Hence

$$P_0 = 4\pi h'D' \quad \ldots\ldots(12).$$

The mass of the second column will be

$$4\pi h''D'' = \frac{4\pi h''D'}{1 + \lambda' t_0} \quad \ldots\ldots(13);$$

and the weight will be $\frac{4\pi h''gD'}{1+\lambda' t_0}$, which is equal to the pressure P on the unit of surface. Hence

$$P = \frac{4\pi h''gD'}{1 + \lambda' t_0} \quad \ldots\ldots(14).$$

So long as the temperature is constant the density is proportional to the pressure; or $P_0 : P :: \triangle_0 : \frac{P\triangle_0}{P_0}$; and under different circumstances of temperature the density is inversely as the volume for the same mass, so that for the temperature t_0 above 32°, the density just found will become $\frac{P\triangle_0}{(1+\lambda t_0)P_0}$, and this must represent the actual density $\triangle$ at the surface of the planet. Hence

$$\triangle = \frac{\triangle_0}{(1 + \lambda t_0)} \cdot \frac{P}{P_0} = \frac{4\pi h''gD'}{4\pi h'D'(1+\lambda' t_0)} \cdot \frac{\triangle_0}{(1+\lambda t_0)} = \frac{\triangle_0 gh''}{h'(1+\lambda' t_0)\,(1+\lambda t_0)} \quad (15).$$

3. Let m be the mass of any one of the planets, that of the Earth being 1, A the mass of the Earth's atmosphere, and KAm that of the planet's, then

$$A = 4\pi h'D' \quad \ldots\ldots(16);$$

$$\text{and } KAm = \frac{4\pi h''D'r^2}{1 + \lambda' t_0} \quad \ldots\ldots(17);$$

and hence

$$\frac{KAm}{r^2} = KAg = 4\pi Kgh'D' = \frac{4\pi h''D'}{1 + \lambda' t_0}, \text{ or}$$

$$h'' = Kh'g\,(1 + \lambda' t_0) \quad \ldots\ldots(18).$$

This value in (15) gives

$$\frac{\triangle}{\triangle_0} = \frac{Kg^2}{1 + \lambda t_0} = \frac{P}{P_0\,(1 + \lambda t_0)} \quad \ldots\ldots(19).$$

Equation (10) is independent of the extent of surface on which the atmosphere presses, since it gives only the law of the variation of density of the atmosphere in ascending through it. R is therefore a linear measure, and on the Earth it has been found from observations to be 26,126.5 English feet, or 4.948 English miles. To compare this with a similar quantity for any one of the planets, we must make $r = 1$ in Eq. (9), and we shall make

$$4\pi R_0 = \frac{P_0}{\triangle_0} \quad \ldots\ldots(20), \quad 4\pi gR' = \frac{P}{\triangle} \quad \ldots\ldots(21),$$

in which $R_0 = 4.948$ miles. These equations give

$$\frac{gR'}{R_0} = \frac{P}{P_0} \cdot \frac{\triangle_0}{\triangle} = 1 + \lambda t_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22).$$

In Eq. (10) we must therefore substitute for R the value $R' = \frac{(1+\lambda t_0)R_0}{g}$, which gives

$$R_0 (1 + \lambda t_0)^2 \log. \frac{\rho}{\triangle} = - gz \left[1 + \frac{r\lambda t_0}{r+z}\right] \ldots\ldots\ldots\ldots\ldots (23).$$

Equation (23) is independent of K, which depends on the mass of the planets' atmosphere, as it should be since we have neglected the attractive influence of the atmosphere. This seems allowable since the mass of the Earth's atmosphere is but a small fraction of the mass of the Earth.

4. Now let $t_0 = 0$ in (23) and the resulting equation will apply to an atmosphere of 32° Fah.

$$R_0 \log. \frac{\rho}{\triangle} = - gz \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24).$$

To make some application of these formulas we shall take $g = 1$ and $\triangle = 2\rho$, and since N log. $2 = 0.6931472$ we find $z_1 = 3.4297$ miles; and for $\triangle = 4\rho$ we have $z_2 = 6.8594$ miles, and so on, $\triangle = 2^n\rho$ giving $z_n = nz_1$.

Now let us suppose $g = 1$ and $\lambda t_0 = 1$, then, $\triangle = 2\rho$, $4z_1 = z + \frac{rz}{r+z}$ $= \frac{z^2 + 2rz}{r + z}$, and $z_1^1 = -(r - 2z_1) \pm \sqrt{r^2 + 4z_1^2}$.

We must reject the negative value, and for the other we have

$$z'_1 = 2z_1 + \frac{2z_1^2}{r} \text{ very nearly, } = 6.8649 \text{ miles.}$$

In a similar manner we find $z'_2 = 13.7425$, or $z'_2 = 2z'_1 + 0.0127$ miles. We should also find $z'_3 = 3z'_1$, very nearly, for $\triangle = 3\rho$; and so on.

We thus see that if the Earth were 490° Fah. warmer than it now is $\left(\text{since it is found that } \lambda = \frac{1}{490}\right)$; or in other words, if its own heat was such as to heat the air in contact with it to 490° more than 32° (supposing it to be 32° now), and to vary according to the law which we have supposed, the density of the atmosphere would be one-half what it is at the surface at the hight of about 7 miles, instead of 3½ as at present; and one-fourth the density would be reached at about 14 miles, and so on. The hight of the atmosphere under such conditions would be more than double what it now is. If we suppose the density at the surface of the Earth to be about a million times as great as at the surface of the atmosphere, or $\triangle = 2^{20}\rho$, we shall find $z = 139$, nearly, under the conditions of high temperature; while in the other case it will be but 69 miles.

For the temperature which we have supposed the Earth to have, it would scarcely give out any light. To suppose the body self-luminous, it will be necessary to make t_0 about twice what we have supposed. We shall now make an application of our formulæ to the planet Jupiter, and since that

planet seems to be brighter, or to give out more light than what it reflects from the Sun, we shall suppose λt_0 equal to 2. The force of gravity on Jupiter is about 2.42 times terrestrial gravity ; and if we make some allowance for an extensive Jovian atmosphere we may perhaps call $g = 2.5$.

If these values be put in Eq. (23), and we make $\triangle = 2\rho$, we shall have $3.6z_1 = \frac{z^2 + 3rz}{r + z}$, and $z = 1.2z_1$ nearly, $= 4.1156$ miles.

If we make $t_0 = 0$ we shall find $z = 1.3718$ miles, or about one-third of the other value. In a similar manner we shall find for the relation $\triangle = 4\rho$, $z = 8.2313$ miles, and so on.

If in Equation (19) we make $K = 1$, and $\lambda t_0 = 2$, we shall have $\triangle = 2\triangle_0$ ..(25) very nearly. Thus at the hight of about 4 miles the density of the Jovian atmosphere will, upon these suppositions, be the same as the density of the Earth's atmosphere at the surface of the Earth. If we suppose, as Mr. R. A. Proctor has done, that the density of Jupiter's atmosphere where the cloud-layers exist, is one-fourth of the density of the Earth's atmosphere at the Earth's surface, we shall have z for that case about 12 miles instead of 100 as he supposes. According to this investigation, then, Jupiter's atmosphere at his surface is either very dense, or its extent is not so great as Mr. Proctor imagines ; or his temperature at the surface is greater than 1000° Fah.

We may perhaps reasonably assume $\triangle = 2^{50}\rho$ on Jupiter, and this value will give the hight of his atmosphere about 206 miles ; and if we suppose $\triangle = 2^{20}\rho$ we shall find z equal to about 82 miles.

If we call $K = 1$, $t_0 = 980°$, $\lambda' = \frac{1}{9800}$, $g = 2\frac{1}{2}$, we shall find, by Eq. (18), the hight of the barometer on Jupiter $82\frac{1}{2}$ inches. By Equation (19), we find upon the same suppositions that the pressure to the square inch, of Jupiter's atmosphere on his surface, is equal to $93\frac{3}{4}$ pounds.

If we take for Saturn $g = 1.1$, $\lambda t_0 = 2$, $\triangle = 2\rho$, we shall find $z = 9.3537$ miles ; and for $\triangle = 2^{20}\rho$, $z = 187$ miles ; and for $\triangle = 2^{50}\rho$, $z = 468$ miles. If we take $K = 1$, Eq. (19) gives $\triangle = \frac{2}{5}\triangle_0$, and the pressure to the square inch equals 18 pounds. The hight of the barometer by Eq. (18) equals 36 inches.

To make some application to the Sun, I shall assume $\lambda t_0 = 49$, which will give a temperature of the Sun's surface sufficiently high to correspond with our knowledge of the subject. We also have g equal to 27.2 ; and if $\triangle = 2\rho$ we find $z = 6.304$ miles. If we suppose $\triangle = 2^{1000}\rho$, we shall have $z = 6304$ miles as the corresponding hight of the solar atmosphere. We also find $\triangle = 15\ \triangle_0$ very nearly, if $K = 1$; and the pressure to the square inch is about 11000 pounds. The hight of the barometer would be 234.6 feet.

In these applications we have assumed $K = 1$ which supposes the mass of the atmosphere proportional to the mass of the planet which it surrounds. In the absence of all real knowledge on the subject we may as well make that assumption as any. The probability is that this supposition is an ap-

proximation to the truth. Equation (23) is independent of any supposition in relation to this matter.

5. In the following table I have arranged the various elements of the planetary atmospheres, which have been the subject of the foregoing investigation, on the supposition that $K = 1$, and $t_0 = 0$.

Planet.	Value of z for $\rho = \frac{2}{\rho_0}$, in Miles.	Density at Surface.	Pressure at Surface on 1 sq. in. in lbs.	Hight of Barometer in inches.	Hight of the Atmosphere in Miles.
Mercury.....	7.40	0.214	3.21	13.9	719
Venus.....	3.92	0.765	11.47	26.2	392
Earth.....	3.43	1.000	15.00	30.0	343
Mars.....	11.31	0.092	1.38	9.1	1095
Jupiter.....	1.42	5.856	87.84	72.6	146
Saturn.....	3.12	1.210	18.11	33.0	313
Uranus.....	5.20	0.530	7.95	21.8	515
Neptune.....	4.36	0.615	9.22	23.5	436

The last column of this table, or that which gives the hight of the atmosphere, is based upon the supposition that the exterior limits of the planetary atmosphere have the same density for all, and that the Earth's atmosphere has a hight of 343 miles. It is not a little curious at first sight that Jupiter's atmosphere should be the least extensive in hight, while Mars's is the most extensive; but this is due to the great attractive influence of the one, and the smallness of the same element in the other. Though this table is based on an uncertain hypothesis, yet it seems to me that it is considerably instructive. Besides, the preceding theory will serve to test some of the hypotheses which are offered to account for the surface appearances of Jupiter.

The peculiar figure which Sir William Herschel found Saturn to present, which Bessel and others could not discover, and which Airy could not explain upon the theory of gravitation, is accounted for without difficulty by the currents in his atmosphere, as will be seen by consulting Wm. Ferrel's *Treatise on the Motion of Fluids relative to the Earth's Surface*, Art. 18, Fig. 1, Vol. I, *Math. Monthly;* and if Jupiter's atmosphere were sufficiently extensive he ought to present a similar figure.

Waterburgh, N. Y., October 19, 1876.

NOTE.

Since the above was written I have seen a report of Prof. S. P. Langley's experiments to determine the temperature of the solar surface. Physicists have heretofore differed considerably in their estimates of the Sun's temperature, Secchi putting it as high as 18 millions of degrees Fah., St. Claire Deville and others, between 3,000° and 20,000°. Prof. Langley's result favors the higher number. For convenience of calculation let us assume the solar temperature equal to 9,800,032° Fah., so that $\chi t_0 = 20{,}000$.

Now let $K = 1$, then we find, by Equation (19), $\rho = 0.0369\,\rho_0$; or the

density of the solar atmosphere at the surface of the Sun, is but little more than one-half the density of hydrogen at the surface of the Earth, and at a temperature of 60° Fah. The pressure on a square inch of surface, is about 11,000 pounds Avoir. In the case of the Earth the density of the atmosphere at the surface of the Earth, is to the density at the surface of the atmosphere, at least as great 2^{100}: 1. If we assume the same ratio to hold for the Sun's atmosphere, Eq. (23) will give us for the hight of the solar atmosphere, 426,000 miles, or about the radius of the Sun. If we make $t_0 = 0$, we shall find the hight of the atmosphere, with the same ratio of densities, about $12\frac{1}{2}$ miles; the density at the Sun's surface about 740 times that of the Earth's atmosphere at the surface of the Earth, or nearly equal to the mean density of the Sun. It will be noticed that in the case of high temperature, if we assume $K = 10$ (a very improbable value, it being too large), we still have $\triangle = 0.369_0 \triangle_0$, which gives a rare atmosphere. The following table will give the density at different hights above the Sun's surface:

Relative Density.	Hight in Miles.	Absolute Density, or $\triangle_0 = 1$.
$\triangle = 1$	0	0.03699
$\frac{1}{2}$	2536	0.01849
$\frac{1}{4}$	5104	0.00924
$\frac{1}{8}$	7702	0.00462
$\frac{1}{16}$	10330	0.00231
$\frac{1}{32}$	13000	0.00116
$\frac{1}{64}$	15683	0.00058
$\frac{1}{128}$	18403	0.00029
$\frac{1}{256}$	21362	0.00014

These numbers will help us to explain the rapid movements which Prof. C. A. Young and others have noticed in the solar atmosphere. If gases are pent up beneath the solar surface, but finally escape with great force, the rare atmosphere of the sun would not retard the motion like a dense one. The less rapid motion may be due to difference of specific gravity. The density of the hydrogen clouds can be calculated from the formulæ which have been given in the text. D. T.

November 24, 1876.

[*Minutes continued from page* 292.]

The minutes of the last meeting of the Board of Officers and Members in Council were read, and the recommendations of the Board were acted upon as follows:

A committee of five, to be appointed by the Chairman, after consultation, was, on motion of Mr. Price, ordered, who should accept Mr. Wooten's invitation, and examine his anthracite slack fires at Reading, or elsewhere along the line of the Reading Railroad.

The curators, on motion of Dr. Cresson, were requested to inquire of the Superintendent of the United States Mint whether it were practicable to arrange for the safe keeping and public exhibition of the cabinet of coins of the Society, in the Mint.

The librarian, was, on motion, authorized to proceed with the printing of the catalogue of the library, beginning with division VI; and directed to report to the Finance committee the plan and cost of the work. The Librarian explained that division VI, VII, and VIII, would make a volume nearly as large as that of division I to V, already published; and that division VI (Sociology, Commerce, Manufactures, War and Law) is ready to go to press, every title having been verified by reference to book or pamphlet. The other divisions (VII, Language, Belle Lettres, Fine Arts, Ethics, Metaphysics, Philanthropy and Religion; and VIII, Biography and Newspapers) will be ready for the press by the time division VI is printed. The press work must attend on a careful proof reading, and be therefore slow. The whole cannot be finished in less than eighteen months.

Pending nominations 809, 810, 811, 812 were read.

The name of Dr. James Gibbons Hunt was ordered to be taken from the roll of members, at his request.

Judge I. I. Hare's resignation on account of his inability to attend any meeting of the Society, was accepted.

Mr. Fraley reported the receipt of the quarterly interest of the Michaux Legacy, due Oct. 1st ult., $145.45, and its payment to the Treasurer.

Mr. Price offered the following resolution, which was discussed and passed:

Resolved, That this Society consents that, after providing for the Michaux grove of oaks, and for cultivation of other oaks in the park nursery, as provided by the resolutions of the Fairmount Park commissioners of March 12 (17?)th, 1870, and agreed to by the society on the 18th of March, 1870, the residue of the income of the Michaux legacy paid over to the Park commission may be applied to the pur-

purchase of other trees; and such other trees as well as oaks may be distributed not only to other parks, but to city squares, and in exchange with other public nurseries, and towards planting the grounds of institutions of learning and charity, to any extent that will not impair the primary purpose of said agreement of March, 1870.

And the meeting was adjourned.

Stated Meeting, Dec. 1st, 1876.

Present, 13 members.

Mr. Eli K. Price, in the Chair.

Letters of acknowledgment were received from the Societies at Göttingen July 15, (Proc. Vol. XIV) and Emden (94), and the Smithsonian Institution, July 22d (97).

A letter of envoy was received from the Society at Emden.

Donations for the Library were reported from the Academies and Societies at St. Petersburg, Berlin, Moscow, Emden, St. Gallen, Cherbourg, and Rotterdam; the Revue Politique, and London Nature; the Royal Astronomical, Geographical and Zoölogical Societies; the Museums at Cambridge, and Albany; New York State Library; Poughkeepsie Society of Natural Science; Professor E. D. Cope; and the Brazilian Centennial Commissioners.

On the report of the curator present of an interview with the superintendent of the mint, it was resolved that the report be adopted and the curators be requested to take such further measures as may be necessary for the placing of the Society's collection of coins under the care of the officers of the United States Mint.

Professor Hart read a paper entitled, "The Fairy Folk, or Fairy Lore of Spencer and Shakespeare," giving the romance or latin origin of the words fairy, &c., in contrast with the teutonic origin of the words elf, &c., assigning different characters to this species of imaginary creatures, supporting the distinction by numerous quotations, and the recital

of numerous typical legends. He defended his theory that Shakespeare's fairy lore was taken wholly from the life of the english people and was essentially and wholly teutonic, while Spencer's fairy characters represented the southern or romantic ideas of the world of enchantment.

The Annual Report of the Treasurer was read.

Pending nominations, Nos. 809 to 812, and new nominations, Nos. 813 to 822, were read.

On motion of Mr. Briggs, it was resolved that the words, "and report to the Society, on the originality of the process of Mr. Wooten, and whether it is deserving of the premium of $500 offered by the Society (Nov. 16th, 1866,) for the utilization of Anthracite Coal Slack," be added to the resolution passed at the last meeting to give it effect.

And the meeting was adjourned.

Stated Meeting, December 15th, 1876.

Present, 15 members.

Secretary, Professor KENDALL, in the Chair.

Mr. Frank Thompson, a newly elected member, was introduced to the presiding officer, and took his seat.

A photograph of Professor Alfred M. Mayer was received for the album, in a letter dated Stevens Institute, Hoboken, Dec. 11th, 1876.

The resignation of Mr. C. E. Smith was received by letter dated Dec. 9th, 1876, and on motion accepted.

The resignation of Dr. F. G. Smith was received through the Treasurer, and on motion accepted.

Letters acknowledging the reception of publications of the Society were received from Prof. Owen, dated British Museum, Nov. 24th (97); the London Statistical Society, Somerset House Terrace, Kings College Entrance, Strand, W. C., Nov. 28th (97); the Victoria Institute, Adelphi Terrace, Strand, W. C., Nov. 23 (97); and the Society of Antiquaries, Burlington House, Piccadilly, London, W. Nov. 22d, (97).

A letter of envoy was received from the Meteorological Office, London, Nov. 1876.

Donations for the Library were received from the Verein für Kunst at Ulm; Geographical Society and Revue Politique, Paris; Meteorological Committee and London Nature; Canadian Naturalist; Vermont Historical Society; Boston Natural History Society; E. L. De Forrest and Silliman's Journal; Editors of the Sanatarian, and American Chemist, New York; Penn Monthly; American Journal of Pharmacy and Medical News; and Bureau of Education at Washington.

A letter being read from the Deputy Secretary of the Commonwealth, dated Bellefonte, Pa. Dec. 2d, 1876, asking permission to copy the MSS. journal of Colonel Bard in 1756, at Fort Augusta, in the library of the Society, for publication in the new series of Archives of Pennsylvania, which was granted.

Mr. Walter made a communication to the Society upon the erroneous nature of certain statements respecting the foundations of the great tower of the Public Buildings at the corner of Broad and Market Streets.

Mr. Walter called the attention of the Society to some remarks which were made at the Stated Meeting held January 21, 1876, in which the foundations of the Tower of the New Public Buildings were referred to in a manner calculated to lead to erroneous impressions, and to shake the public confidence in that great work.

The remarks alluded to are found on page 181, Vol. xvi, No. 97, of the Proceedings, and are as follows: "Mr. Blodget recounted the experience of those who laid the foundation of the Masonic Temple, Broad and Filbert, where two gravels were found separated by three feet of quicksand, which required two powerful steam pumps 6″ and 8″ working night and day. The top of the quicksand layer was accidentally uncovered at the corner of the lot 40 feet deep, and this obliged the plan for laying the foundation to be entirely changed, at an expense of say $30,000.

"The great Tower of the Public Buildings, opposite to the Masonic Temple, has its foundation laid in the upper gravel, and there is a possibility of future disaster from the subjacent quicksand."

Mr. Walter stated that the foundations of the tower of the Masonic Temple were laid in what was formerly a ravine, as the dip of the strata underlying the Penn Square site clearly indicates, so that the vertical section of the excavations for the towers of the Temple will be found to be

very different from that of the excavations for the tower of the Public Buildings, and can in no wise be accepted as an indication of a want of stability in the underlying strata of the latter structure. He remarked that he obtained from Mr. Windrim, the Architect of the Temple, a memorandum of the thickness and character of the several strata through which the excavation passed, in reaching the foundation of the Tower, and which does not agree, in any particular, with the statement recorded in the proceedings of the Society.

According to Mr. Windrim, the first, or upper stratum was 10 feet in thickness, consisting of a sandy loam, resting on a clay bed of 5 feet deep, underlying which occurred a stratum of sandy loam 12 feet thick ; at about 2 feet from the bottom of this, or 25 feet below the street curb, the loam was permeated with water, supposed to have percolated through the ground when the adjacent squares were open. The next 10 feet consisted of stratified gravel, at the bottom of which it became hard, and at the depth of 1 foot more, being 38 feet below the street curb, the foundations were laid in a substratum of hard, compact gravel.

Mr. Walter remarked that he considers it proper thus to refer to the foundations of the tower of the Masonic Temple, as the statement in the Society's proceedings deduces from what is there erroneously said respecting the Masonic structure, that there existed a possibility of future disaster to the great tower of the Public Buildings. Such an inference is not only unfair and unjust, but it is damaging to public confidence in a great public work, and highly detrimental to the professional reputation of its architect.

The error of such an inference cannot fail to be apparent in view of the actual geological formation of the strata in which it is founded, and the manner of its founding. It is altogether a mistake to suppose that this great tower has its foundations "laid in the upper gravel." The facts are that in digging the foundation in question the first stratum passed through was the ordinary sandy loam, under which occurs a clay bed varying from 4 to 6 feet in thickness ; then follows a stratum of gravel, and below that one of sandy loam stratified with gravel and permeated with water from the surface drainage, producing what is sometimes called quicksand ; underlying this the hard gravel commences, and continues increasing in density as it increases in depth, until it assumes the character of "water gravel," from which rises the natural flow which supplies our wells. This stratum is some 10 feet in thickness, and in this the Tower of the Public Buildings is founded. After the excavation had been made, and prepared to receive the structure, a well was dug in the centre for the purpose of ascertaining the nature of the underlying soil, when it was found to consist of hard gravel, solid and compact throughout. This heavy stratum of gravel through which the natural spring water percolates, being considered by architects as the best possible foundation for a heavy structure, rock alone excepted.

Mr. Walter further stated that the foundation of this great Tower is 96

feet square, and 8 feet 6 inches deep, containing about 78,000 cubic feet, consisting of one entire mass of solid concrete, covering the whole space, and pressing equally upon its gravel bed, with which it in some measure necessarily amalgamates; and that in view of these facts, and of all the skill, care, and foresight that have been exercised in founding this, the greatest tower of the world, we need be under no apprehension of "the possibility of future disaster" to the structure.

Mr. E. K. Price, as Chairman of the Committee on the application of one-half of the income from the Michaux Legacy to botanical purposes, made a report on the Michaux and Cresson Trusts.

On motion it was: Resolved, that five hundred extra copies of the Report be printed for circulation and future use in the execution of the Trusts of the Cresson and Michaux Trusts.

Mr. Lesley read a paragraph from a recent private letter of M. Leo Lesquereux respecting new discoveries in the Carboniferous Flora of North America.

Mr. Lesley communicated a collection of Oil-well records made by Mr. J. F. Carll, Assistant on the Geological Survey of Pennsylvania, in charge of the survey in the Oil Regions of the State, with remarks on their value to men abroad and at home.

Professor Chase called attention to the Swedish statistics of color blindness.

Mr. Thompson described the investigations carried on at the shops at Altoona by the Pennsylvania Railroad Company, into the values of various signal lights and their possible combinations; and stated that in the experiences of that company not a single instance had been found among the employés of such color blindness as practically incapacitates an employé from using the series of four colors, white, green, red, and blue, to which signal lights are confined.

The report of the Finance Committee was read.

The annual appropriations for the ensuing year recommended in the report were, on motion, ordered.

Pending nominations, Nos. 809 to 822, and new nominations, 823 to 829, were read.

And the meeting was adjourned.

The Michaux Trees.

(*Report of Committee read before the American Philosophical Society, December* 15, 1876.)

To the American Philosophical Society and to the Fairmount Park Commissioners:

The Chairman of the Committee on the Michaux Fund of the said Society, and of the Committee on Trees and Nurseries of the latter, respectfully reports:

That he regards this year, 1876, as an era, from which will date a large advancement in the matters under the care of said Committees. Before it began very valuable importations of the rarest oaks had been made and planted in the Park Nursery, from which the first transplantations have lately been made into the Park grounds, and a few of them have been ordered into the *Campus* of the University of Pennsylvania this fall. Some planting out of the various trees in the Nursery had been made in the Park along the few avenues opened, and 1639 trees have been planted over the space occupied for the Centennial International Exhibition. The formation of the grounds within that space by the Board of Finance of the Exhibition and the planting therein are an invaluable acquisition to the Fairmount Park, as open waste fields have thereby been converted into beautiful gardens, with avenues, walks and fountains. It is true, that the garden of the Horticultural Hall was, to a large extent, planted with trees and flowers by Foreign and American exhibitors. James Veitch & Sons, of King's Road, Chelsea, S. W., near London, presented to the Park Commissioners their valuable collection of trees and plants, consisting chiefly of Rhododendrons.

The American exhibitors who had collected and planted in the garden of Horticultural Hall a rare variety of trees and ligneous plants were Thomas Meehan, of Germantown; Hoopes, Brother & Thomas, of West Chester, Pa.; S. B. Parsons & Sons, and R. B. Parson & Co., of Flushing, N. Y.; Miller & Hayes, of Mount Airy, Philadelphia; Mahlon Moon, of Morrisville, Pa.; and Robert Buist, of Philadelphia. They were actuated by a liberal desire that their collections should remain in the Park, and offered them at prices which they esteemed little over half the cost to them. It was an object to the Commissioners to secure these permanently for our Park, to be transplanted as thinning out shall be required for their healthy growth, and they have been secured by purchase.

The resources for this purchase should be here stated. They were as follows:

The city's appropriation, by the Park Commission applied for Nurseries in 1876	$1,500 00
Accumulated Interest on Elliott Cresson's Legacy	3,000 00
" " André F. Michaux's Legacy	414 60

Contributions by the following persons of $100 each, to wit:

William L. Schaffer, George C. Thomas, Charles H. Rogers,

Samuel Jeanes, Joseph Jeanes, Joshua T. Jeanes, Isaac F. Baker, Eli K. Price	$800 00
Moses Brown and J. C. Strawbridge, each $50	100 00
Together	$5,814 60

As the legacies of Elliott Cresson and André F. Michaux are enduring funds for planting in the Fairmount Park and elsewhere, it is proper here to show what are the trusts of those wills, and what are the obligations to the public incurred by the Park Commission in executing the agency committed to them.

ELLIOTT CRESSON'S LEGACY.

Elliott Cresson, by his last will and testament, made in 1857, provided as follows:

"I give and bequeath to the Mayor and community of Philadelphia the sum of $5,000, in trust, as a perpetual fund, the income of which I desire shall be annually, forever, expended in planting and renewing shade trees, especially in situations now exposing my fellow citizens to the heat of the sun."

An ordinance to provide for the investment of the principal and the application of the income of the Legacy of Elliott Cresson, Esq., to the City of Philadelphia, was passed June 10, 1859.

"A SUPPLEMENT

"*To 'An Ordinance to provide for the investment of the principal and the application of the income of the Legacy of Elliott Cresson, Esq., to the City of Philadelphia,' approved June* 20, 1859.

"Section 1. The Select and Common Councils of the City of Philadelphia do ordain, That the income of the fund bequeathed to the City of Philadelphia by Elliott Cresson, Esq., shall be expended in accordance with his will, by the Commissioners of the Park, constituted pursuant to the Act of Assembly, approved March 20, 1867."

The will of André Francois Michaux, of Vawreal, near Pointoise, France, dated the 4th September, 1855.

It revokes former wills. It declares as follows:

"Wishing to recognize the services and good reception and the cordial hospitality which my father and myself, together and separately, have received during our long and often perilous travels, in all the extent of the United States; as a mark of my lively gratitude, and also to contribute in that country to the extension and progress of agriculture, and more especially in sylviculture in the United States; I give and bequeath to the American Philosophical Society, at Philadelphia, of which I have the honor to be a member, the sum of twelve thousand dollars (at 5.50 the dollar, 64.800 francs). I give and bequeath to the Society of Agriculture and Art, &c., in the State of Massachusetts, Boston, in which I have the honor to be a member, the sum of eight thousand dollars (at 5.10 the dollar is, 43.200) these two sums together making one hundred and eight thousand francs, or again twenty thousand dollars. I give and bequeath the sole ownership

to these two above said Societies, and the usufruct to my aforesaid wife for her life."

The American Philosophical Society, believing that they could best execute their trust as to half the income of the Michaux Legacy in the Fairmount Park, made the following arrangement for that purpose:

"*Office of the Commissioners of Fairmount Park, No. 224 South Fifth Street, Philadelphia, March 12th,* 1870.

"At a meeting of the Commissioners of the Park, held this day, the following preamble and resolutions were adopted:

"*Whereas,* The American Philosophical Society has made a communication to this commission, proposing that the name of André Francois Michaux, who traveled long in this country, and described our oaks and forest trees in a work of great merit and splendor, should have his name, and that of his father (who had, by like travel and study rendered service to science,) honored in the Fairmount Park, in a manner, to be a memorial to their devotion to science, and to promote the objects which had occupied their lives, and has proposed, after the death of the widow of André Francois Michaux, to devote the interest or income of six thousand dollars bequeathed by him to said Society, to be expended in execution of the trust of his will in the said Park, for the purpose following; therefore,

"*Resolved,* That there shall be a grove of oaks in the Fairmount Park, forever, to bear the name of 'The Michaux Grove,' in which, if practicable, shall grow two oaks of every kind that will endure the climate.

"*Resolved,* That any surplus of revenue received by the commission from the Michaux Fund, after satisfying the requirements of the preceding resolution, shall be devoted to the cultivation of oaks of every variety capable of cultivation in our climate, in the Park nursery; which oaks, to the extent of two of each kind cultivated, be hereafter distributed to other Public Parks in the United States, under proper regulations to be hereafter prescribed."

Resolved, That this Society do agree to the terms contained in the preamble and resolutions of the Fairmount Park Commissioners, adopted on the 12th day of March, 1870, in the expectation and confidence that the planting of the Michaux Grove of Oaks may soon be commenced, so that the Grove shall early become one of the attractions of the Park." Proceedings, Nov. 83, p. 312.

There appearing to be scope for a more extended benefit to be accomplished within the intention of Mr. Michaux, the powers of the Park Commission were extended by the American Philosophical Society.

At a meeting of the American Philosophical Society, November 17th, 1876, it was

Resolved, That this Society consents that, after providing for the Michaux Grove of Oaks, and for cultivation of other oaks in the Park Nursery, as provided by the resolutions of the Fairmount Park Commissioners, of March 12th, 1870, and agreed to by this Society on the 18th of March, 1870, the residue of the income of the Michaux Legacy paid

over to said Park Commission may be applied to the purchase of other trees ; and such other trees as well as oaks may be distributed not only to other Public Parks but to City Squares, and in exchanges with other Public Nurseries, and in planting the grounds of Institutions of Learning and Charity, to any extent that will not impair the primary purposes of said agreement of March, 1870.

In respect to the intention of Elliot Cresson's will, to wit, "in planting and renewing shade trees, especially in situations now exposing my fellow citizens to the heat of the sun," the testator is to be taken to mean the greatest good to his fellow citizens by the shade of trees, and that would be where they most frequent, consistently with the requirements of business. It would not be to place trees in the thronged streets where such plantings would be obstructive and mask all business signs ; but would properly be in all our public squares ; in streets where people are yet so few as to permit the growth of trees without unduly obstructing passengers ; certainly in the East Park, as Mr. Cresson knew it ; and with a necessary expansion as business shall extend, to drive away such planting, and to follow the growth of the city, as the citizens move outward, and the Parks as they shall become more central and thronged. Charities are to be executed as near the intention as reasonably practicable ; City and Girard heirs, 9 Wright's Reps. 9 ; and follow the growth and needs of their objects.

The Park Commission have from the Michaux legacy made importations that have given them the best collection of young and rare oaks in the country, containing about 1200 growing trees.

From the income of the Cresson legacy they have supplied two hundred dollars for trees in Independence Square, and have voted six hundred trees for the other Public Squares, from the Park Nursery ; and two hundred and fifty trees for planting round the grounds of the University of Pennsylvania, and the University Hospital. The contiguous streets opened through the Almshouse ground, and elsewhere as new streets shall be opened, or built upon, might be supplied with trees from the Park Nursery.

There are now growing in the Park Nursery nearly eighty thousand trees and shrubs, of which about thirty thousand are of a size to plant out. Of the latter, there are, of *Arbor Vitæ*: American, 5,000; Siberia, 711; Tom Thumb, do., 1,047; Globe, do., 150; Hovey, do., 350; of White Pine, 350; Australian Pine, 200; Scotch Pine, 200; Balsam Fir, 600; Junipers, 370; Norway Spruce, 2,400; White do., 850; Hemlock, 500; Golden Willow, 32; Sweet Gum, 350; Tulip Poplar, 700; Cypress, 360; Forsythea, 400; Althea Var., 200; Mahonia, 30; Althea, 5,200; Norway Maple, 500; Privet, 150; European Larch, 30; European Birch, 240; English Elm, 400; Sugar Maple, 350; American Ash, 800; American Elm, 1,000; Kentucky Coffee Tree, 100; European Oaks, 800; American Chestnut, 25; Hornbeam, 3,128; American Beech, 50; European Beech, 2,000; Turkey Oaks, 350; Mist Tree, 200; American Larch, 200; Green Poplar, 96; Silver Maple, 440.

The City Councils and other officials will be authorized to draw on the above stock of trees, to the extent of the fulfilment of the trusts under the

wills of Cresson and Michaux, through the Park Commission, and even beyond those limits no doubt the Commission would consent for the public Squares, streets and Institutions.

Within the Park the Landscape Gardener will exert his skill to blend in beauty the self-sown forests there growing, with artistic planting, as the formation of new avenues and fresh grading will demand; where the new trees will be of kinds not native to our environs, and show in contrast the hand of Art; but at the same time greatly add to the variety and novelty of the trees and plants; so that the trees of the Park shall become a great *Arboretum*, and its flower beds become Botanic Gardens. Thus the landscape formed to please the taste, and the gardens to delight the eye, will become Schools of Science for all scholars and citizens. For this end, each section of the Park will be planted with the largest practicable variety of trees and plants.

That the variety of these may be greatly increased, we have purchased the trees exhibited in Horticultural Garden, and the gathering and planting of acorns and tree seeds have had in view mainly to increase the number of species, while providing the necessary stock whence to transplant trees over our Park of nearly three thousand acres in extent.

It is with pleasure I name those who have afforded the Committee cordial aid in supplying trees, acorns and tree seeds for the Fairmount Park during this Centennial year. They are, Dr. George B. Wood; Dr. George Smith, of Delaware County; Isaac Martin; Thomas S. Chambers; Mr. Smedley; Israel Lamborn, of Chester County; Dr. Kirkbride; Aubrey H. Smith; Philip C. Garrett; Isaac F. Baker; Clarance H. Clark; Dr. Morris Longstreth; Isaac Burke; George Stockham; Burnet Landreth; Thos. L. Craig, of Philadelphia; David Marshall, of San Francisco; Rollo Nichols, of Conn.; and Samuel Davenport, of South Australia, Commissioner to the Centennial Exhibition.

Through the latter the Committee received a collection of tree seeds from Tasmania; and have been informed of others on the way from South Australia. Mr. Davenport hopes to furnish the seeds of a Mountain Eucalyptus, with antimalarial potency, that will stand our climate.

The acorns and tree seeds furnished to the Park Nursery, have been, English White Oak, European Oak, Overcup White Oak, Post Oak, Chestnut White Oak, Weeping Oak, Willow Oak, Spanish Oak Acorns, Red Oak, Scarlet Oak, Pin Oak, White Oak, Turkey Oak, Bartram Oaks.

The American Ivy, Yellow Locust, do., pseudaccasia, Kentucky Coffee tree, Silver Ash, Black Ash, Horse Chestnuts; Larch, European and American; Nettle tree, Paw-paw, Magnolia, Flowering Crab Apple, Carolina and Green Buckthorn, Firethorn, Dogwood, Silver Bell, Winterberry, Blackhaw, Japan Callicarpa Cerulea, Skimmia Japonica; Celastris Scandens; Chinese Bignonia, Laburnums, Horse Chestnuts; White Birch, English Ash, Catalpa, Tulip Tree, Elm, Oriental Plane Trees.

Of Maples, Norway, Sycamore, Purple-leaved, Currant-leaved, Sugar and Rock Sugar.

Nor have we failed to think of the boys and girls of future times, and have planted and provided for the planting of the nuts of the Shellbark Hickory, large and small, English and black Walnuts, Chestnuts and Chincopins; the Nutmeg Pine.

Many of the above varieties of acorns and tree seeds have been supplied through Samuel Davenport to four Provinces of Australia, to wit: Victoria, Tasmania, Queensland, and New South Wales; and also to Dr. Schomburgk, of Adelaide, S. A.; to the Phillipine Islands, through Mr. Sebastian Vidal, Spanish Commissioner for the preservation of the forests of those islands; to Japan, through Rev. E. R. Beadle. The supply of acorns and tree seeds has been procured without any cost to any public or trust fund.

The Park Commission have received from Mr. Jacob Hoffner, of Cincinnati, Ohio, a Sago Palm, now in Horticultural Hall, formerly owned by Robert Morris and Henry Pratt, when they owned Lemon Hill, which plant is now supposed to be about 130 years old.

It is in this Centennial year that the artistic planting of the Park has fairly begun; and with the stock of trees on hand in the nursery, with moderate additions for the sake of variety, the formation of the landscapes may steadily proceed, without any serious expenditure, towards completion, as far as such work will admit of completion; for always old trees must decay, to be replaced by those that are both young and new. To fail to meet the annual expenditure for such purpose would be to fail to realize two great purposes of acquiring the Park, namely, the health and enjoyment of the people, and the increase of the resources of taxation commensurately with the interest of the capital invested in the Park. The Park must both be kept beautiful and attractive and the purity of the water supply preserved, or we become delinquent in performing a great duty towards our City, State and Country.

Fault has been found for delay in planting trees in the Park. This complaint is partly to be answered, if not fully, by the fact that it was necessary first to purchase the lands in the Park from many owners, including building lots in six village plots, necessarily a work of time, and after the purchases the ground had to be, and is yet to be, planned, graded, and avenues opened, before it could be known where to plant trees; and the Centennial International Exhibition necessarily caused delay in planning the West Park. There has been such delay during which it is to be regretted trees have not been growing; but that regret will be lessened when we reflect that the planning and planting can now go on rapidly, and be adapted to the buildings and gardens in the exhibition grounds with now an adequate supply of trees at command, and competent skill employed for planning and landscape gardening. These advantages will probably compensate for the loss by delay; and, indeed, more than compensate for them. Let us now proceed with such earnestness that the era of our Park's great improvements shall date from our National Centennial Year.

ELI K. PRICE, *Chairman, &c.*

Oil Well Records, selected from the collections of Mr. J. F. Carll, Assistant Geologist in charge of the Geological Survey of the Oil District of Pennsylvania. Communicated by J. P. Lesley, State Geologist.

(*American Philosophical Society, Dec.* 15, 1876.)

I hope to present at another meeting my views of the value of these records, and an analysis of the conclusions arrived at by Mr. Carll from a comprehensive study of many hundreds of such records collected by him during the last three years, since the commencement of the Second Geological Survey of the State in 1874; as well as from his practical experience of operations in the Oil Region since 1865.

The scientific value of well records is indeed limited by many conditions, each of which should be separately considered. But there can be no question of the utility of preserving them from destruction by publishing them in the printed archives of a society like this. Their publication will answer many questions put by men of science abroad and at home; will place at the service of investigators the original data of our own calculations; will invite the intelligence of thoughtful men in the Oil Region to a more careful scrutiny of such data; and above all, will induce many well borers to be more precise and complete in making up future records, and perhaps to communicate them for comparison. In this way only will it be possible to arrive at broad and true answers to moot questions which no one has yet succeeded in satisfactorily answering, except in a very local and unconnected manner.

Technical names and terms ought to be explained to those who have no business at the wells, but such a glossary would be a long one.

The height of each well mouth above the fixed ocean level datum of the Coast Survey should always be given; but it is often wanting, and then the value of the well record becomes comparatively low.

The well records of one locality have been grouped together; but it must be understood that not one in ten has been obtained, and the whole list is therefore but a meagre selection.

The first groups have been obtained from Companies operating in Warren and Venango Counties; others might have been added from Clarion and Butler Counties as specimens of the collections made in those Counties, to be published hereafter to show the geological persistency of the Oil-Sand Group from Tidioute to Butler.

Colorado Well, No. 1.

August 12th, 1870.

Located in Warren County, Southwest Township, Pa. on Pine Creek, or East Oil Creek, between Pleasantville and Tidioute, and two miles northeast of Enterprise.

Level of well mouth above ocean level in feet.*				1367
Casing to rock	36	to	36	= 1331

* On the provisional assumption that Oil City Depot is 995′ above *mean high tide P. R. R. datum;* and 7′ added for ocean level in Raritan Bay.

Interval of measures unnamed.....	236	to	270	=	1097
First Sand (1st S. S.).....	57	"	327	=	1040
Interval unnamed.....	88	"	415	=	952
Second Sand (2d S. S.).....	24	"	439	=	928
Interval unnamed.....	81	"	520	=	847
Third Sand (3d S. S.).....	46	"	566	=	801
Well carried down in "Pocket".....	9	"	575	=	792

Size of hole $5\frac{1}{2}''$; drilled wet; cased with $3\frac{1}{4}''$ casing to shut off the water. Seed bag on casing below 2d S. S. say at about 445′.

A "mud vein" 8′ below top of 3d S. S. at 528′.

The oil sand was of uniform color [white and pebbly] with the softest stratum on top, and appearances indicate that nearly if not quite all the oil comes in the well at 5 or 6 feet below the top of the 3d sand, between which points both torpedoes were exploded.

This well was pumped about thirty days, part of the time with a gas pump attached and part of the time without one.* The largest natural production without the gas pump was 4 barrels per day. The first day after the gas pump was applied the production increased to 6 barrels, from which point it gradually declined to less than 4 barrels.

On the 21st of November, 1870, it was torpedoed at a point $5\frac{1}{2}$ feet below the top of the 3d S. S. It then produced 160 barrels per day for the first few days, but gradually declined to 13 barrels per day by the 1st of June, in the following year, 1871. The gas pump was again tried with no satisfactory results, and taken off as worthless or of no benefit to the well.

On December 21st, 1871, the production had declined to 10 barrels. A one quart nitro-glycerine torpedo was then exploded in the oil sand, which increased the production to 40 barrels per day. But this continued only a day or two. It immediately commenced decreasing, and on the 1st of August, 1872, about two years from the time it was first pumped, it had declined to its first natural production of 4 barrels per day.

During this month, August, 1872, the "volcanic treatment" was tried upon the well at three different times. The first time 4 burners were used, resulting in a slight increase of gas, but no increase of oil.†

The second time 7 burners were used, same results.

* Every oil well has more or less gas, which, separating from the oil at the bottom of the well rises between the tubing and casing and escapes through a pipe provided for the purpose, at the well mouth. A "gas pump" is an instrument which is attached to this escape pipe to relieve the rising gas from atmospheric pressure and thus facilitate and increase its flow. In many cases it not only augments the flow of gas but very materially improves the oil production of the well. A "Rotary" or "Gas Blower" is sometimes used for the same purpose.

† The "volcanic burner" is a patented article designed to increase the production of a well by intensely heating the fluid at the bottom. It consists of a case filled with chemical ingredients. After lowering it to the desired spot the materials are ignited by an electric spark. The operation is repeated until the desired heat has been obtained, when the tubing is at once put in and pumping resumed.

The third time 9 burners were used, same results, leaving the well at the end of the treatment with an appreciable increase of gas, but no improvement in the supply of oil.

A "scratcher" was also used in this well once, but with no benefit.*

By a series of experiments in casing and pumping, the salt water is supposed to come into the well with the oil near the top of the 3d S. S.

Colorado Well, No. 2.

Located on Colorado Oil Tract, 15 rods south of No. 1, and at the same altitude.

Dry cased hole. Salt water in second sand. Cased below second sand. Produced no oil and only about a quarter of a barrel of salt water per day.

Sand rocks about the same thickness as in well No. 1, but the third sand was of inferior quality, very little of it being white.

Colorado Well, No. 3.

August 20th, 1870.

Located 13 rods, N. 78° E., from No. 1.

Level of well mouth above ocean level in feet†					1404
Casing to rock	34	to	34	=	1370
?	279	"	313	=	1091
1st S. S.	44	"	357	=	1047
?	97	"	454	=	950
2d S. S.	21	"	475	=	929
?	84	"	559	=	845
3d S. S	45	"	604	=	800
? pocket.	8	"	612	=	792

Mud vein in 3d S. S. at 566 feet.

Cased at 475 feet.

3d S. S.
- top 6′ gray, with but little white.
- next 2′ white and soft (good).
- next 20′ white, but close.
- bottom 17′ mixed gray and white.

When first pumped it yielded only one barrel of oil per day and continued thus until a "scratcher" was used, which brought the production up to 15 barrels for a few days. It then declined to 4 barrels when a three pint nitro-glycerine torpedo was inserted 6 feet from the top of the third S. S. After this it produced 100 barrels per day for a short time.

* A "scratcher" is a round brush, about three feet long, made of steel wire. When it is to be used the tubing is drawn from the well, a few barrels of benzine are poured in and the scratcher is attached to the sucker rods and run down to the oil rock, where it is worked up and down for some time to scratch or scrub the walls of the well and assist the benzine in the dislodgment of whatever may have accumulated there.

† Oil City Depot provisionally 995 + P. R. R. datum.

The use of benzine in this well gave no satisfactory results, probably on account of salt water.

Three pint torpedo exploded 8 feet below top of 3d sand, May 30th, 1872. Daily production increased to 10 barrels, but declined to 5 barrels in 10 days. Torpedoed again, Dec. 18th, 1872. Result not stated.

Colorado Well, No. 4.

August 20th, 1872 (?).

Located 5½ rods S. E. of McKinney's N. E. corner.

Level of well mouth 26′ lower than No. 1*.....					1341
Drive pipe to rock.....	31	to	31	=	1310
?.....	205	"	236	=	1105
1st S. S.....	45	"	281	=	1060
?.....	109	"	390	=	951
2d S. S.....	21	"	411	=	930
?.....	84	"	495	=	846
3d S. S.....	43	"	538	=	803
?.....pocket.	6	"	544	=	797

Drilled dry. Cased at 412 feet.

Best natural production, 2 barrels per day.

The hole was dry when the 3d sand was struck, and remained so until the drill had penetrated the 3d sand 5½ feet. At this point oil and salt water came in. The best part of the sand was from 505 feet to 515 feet; below this the sand was poor.

The first torpedo was exploded			5	feet	below top of rock.	
" second	"	"	10	"	"	"
" third	"	"	5	"	"	"
" fourth	"	"	15	"	"	" May 4th, 1872.

The production was increased by the first torpedo but soon settled back to about 5 barrels per day. The same effect followed the second and third. The fourth was a one quart nitro-glycerine blast, but it made very little increase in the oil flow. Benzining, flooding the sandrock with oil, and "scratching" the walls, all failed to produce beneficial results.†

* Oil City Depot provisionally 995′ + P. R. R. datum.

† A well is "flooded" by pouring sufficient fluid in at the top, while the pump remains idle, to fill up the shaft several hundred feet, more or less, above the oil sand. Benzine and crude oil are both used for this purpose; the object being to saturate the rock, under pressure, in order that the paraffin or other accumulations which may have adhered to its surface or obstructed its pores may be loosened and removed with the fluid when the pump is again started.

Colorado Well, No. 5.

Struck about August, 1871.

Located 14 rods south of No. 4.

Level of well mouth above ocean level, No. 1 + 31′ =*					1398
Drive pipe to rock	70	to	70	=	1328
1st and 2d Sands and intervening measures "regular" to top of 3d S. S.	423	"	493	=	905
3d S. S.	43	"	536	=	862
? ....pocket.	7	"	543	=	855

Wet hole. Cased at 217 feet. Crevice in 3d sand 11 feet below the top.

Natural production 60 barrels per day at commencement, but declined quite rapidly to 15 barrels. Remained thus for some time until torpedoed when it declined to 10 barrels.

First torpedo exploded 5 feet below top of 3d S. S.
Second " " 11 " " "
Third " " 5 " " "
Fourth " " 26 " " "

The production steadily declined; no beneficial results following the use of any of the torpedoes, except a slight temporary increase from the last.

The volcanic treatment was also tried without any marked effect.

The 3d sand was better than the average sands of other wells drilled in this neighborhood. The best and softest stratum commenced 3 feet below the top of the rock and continued to 7 feet. From 11 feet downward to the bottom of the rock the sand was good, but not as soft as in the upper division.

Colorado Well No. 6.

August 16th, 1871.

Level of well mouth above ocean*					
Casing to rock	32	feet.	32	=	
?	318	to	350	=	
1st S. S.	40	"	390	=	
?	107	"	497	=	
2d S. S.	19	"	516	=	
?	81	"	597	=	
3d S. S.	46	"	643	=	
? ....pocket.	8	"	651	=	

Wet hole, cased at 516.

Third sand very close and hard. Natural production less than 1 barrel per day.

First torpedo exploded 7 feet below top of 3d S. S. Production increased to 10 barrels but soon declined to 5 barrels.

Second torpedo 6 feet lower. Increase to 10 barrels but for shorter time than the first.

Scratched, with no benefit.

* Oil City Depot provisionally 935′ + P. R. R. datum + 7 for ocean level.

Third torpedo, May 8th, 1872, 7 feet lower than the second. Slight increase in oil.

Fourth torpedo, July 13th, 1872. 5 feet below top of 3d S. S., and 2 feet above the point at which the first was exploded. Increased production but did not pay for cost of torpedoing.

Abandoned August 2, 1872.

Colorado Well No. 7.

Struck August 8th, 1871.

Level of well mouth above ocean.....				
Drive pipe to rock.....	75 feet.		75	=
?.....	190	to	265	=
1st S. S.....	25	"	290	=
?.....	79	"	369	=
2d S. S.....	15	"	384	=
?.....	96	"	470	=
3d S. S.....	43	"	513	=
?.....pocket.	8	"	521	=

Wet hole. Cased at 386.

Mud vein 12 feet below top of 3d S. S. Natural production 7 barrels per day for a few days.

Third sand poor. From marks of oil on the tubing while the well was being pumped, it was inferred that the oil came in at a point in the sandrock just under the "mud vein," say from 12 to 15 feet below the top of the sand.

A three pint nitro-glycerine torpedo was discharged at the point in the sandrock where the oil appeared to come in. The production rose at once to 40 barrels per day, but declined rapidly to 20 barrels and then slowly to 17 barrels, at which figures it remained for more than three months, when it was flooded with water from well No. 10, then drilling within 15 rods of No. 7. When No. 10 was completed and tubed, and the water in it partially exhausted, this well, No. 7, began to recover its oil, but not in so large quantities as before it was flooded. From the time No. 10 began to pump oil, in January 1872, until July of the same year, No. 7 slowly declined in production and at the latter date was pumping only 2 barrels per day.

It was then torpedoed again at the same point as at first, after which it yielded, for a short time, 25 barrels per day and then declined rapidly to 4 barrels.

During the great "shut down movement of October, 1872," when all the walking-beams in the Oil Regions were stopt for 30 days, this well lay idle. But on starting up again in November, it produced 40 barrels per day for three days. Seven days later it was producing 8 barrels, and at the end of one month had settled to its old production before the "shut down," say 4 barrels.

Colorado Well No. 8.

Struck November, 1871.

Level of well mouth above ocean.....				
Casing to rock.....	10 feet.		10	=
?.....	268	to	278	=
1st S. S.....	30	"	308	=
?.....	102	"	410	=
2d S. S.....	20	"	430	=
?.....	85	"	515	=
3d S. S.....	46	"	561	=
?.....pocket.	4	"	565	=

Drilled dry. The casing was first put in at 180 feet. Failing to shut off the fresh water, it was drawn and the large hole continued down to 278 feet. At this point it was cased again, but both fresh water and salt water came in below as the drill went down, and the casing had to be drawn the second time. The well was then reamed down to the second sand, and 432 feet of casing put in, after which the hole remained perfectly dry until the oil sand was reached.

The upper 20 feet of the 3d S. S. was good. The lower (26 feet) was finer, of a grayish color and intermixed with white pebbles. When the 3d S. S. was struck, gas came in very freely and the hole quickly filled up many feet with oil and salt water.

Natural production 1½ barrels per day.

Torpedoed November 21, 1871 with 2 quarts of nitro-glycerine. Exploded 6 feet below top of 3d S. S. Result, 7 barrels per day. Declined rapidly.

Torpedoed December 15, 1871 with 3 pints of nitro-glycerine. Exploded at top of 3d. S. S. Result, not satisfactory.

Torpedoed May 2, 1872 with 1 quart nitro-glycerine. Exploded 15 feet below top of 3d S. S. Result, slight improvement.

Abandoned November 7, 1872.

Colorado Well, No. 9.

November, 1871.

Level of well mouth above ocean*.....					1508
Conductor to rock.....	18 feet.		18	=	1490
?.....	395	to	413	=	1095
1st S. S.....	28	"	441	=	1067
?.....	119	"	560	=	948
2d S. S.....	25	"	585	=	923
?.....	77	"	662	=	846
3d S. S.....	48	"	710	=	798
?.....pocket.	6	"	716	=	792

Drilled dry. Cased at 417½ feet.

Sand generally good.

Natural production about 3 barrels for a short time.

* Oil City Depot provisionally 935′ + P. R. R. datum.

Nov. 29th, 1871. A two quart torpedo was used 11 feet below top of 3d S. S. Result, 10 barrels per day at first, with rapid decline.

Dec. 11th. A two quart torpedo was exploded at 6 feet in the sand. Result not as satisfactory as from the first one. On May 21, 1872, the production had decreased to less than 2 barrels per day. A 3 pint torpedo was then put in 17 feet below the top of the sand. Production for the next four months, 4 barrels per day. After the "30 days shut down" of Oct. 1872, it started to pump at less than 1 barrel per day, and with very little gas. This decline was attributed to the pumping of the wells on the adjoining tract after this one had been stopt.

Nov. 26th, 1872, it was treated with 6 volcanic burners, but with very slight improvement.

Dec. 7th, 1872, exploded a 3 pint torpedo 20 feet below the top of sand. Increase in oil very slight.

June 24th, 1873. Production, half barrel per day.

Colorado Well, No. 10.

January 10th, 1872.

Level of well mouth above ocean.....				
Drive pipe.....	42 feet.		42	=
?	198	to	240	=
1st S. S.....	40	"	280	=
?	89	"	369	=
2d S. S.....	14	"	383	=
?	87	"	470	=
3d S. S.....	43	"	513	=
? .....pocket.	9	"	522	=

Wet hole. Cased at 274 feet, $3\frac{1}{4}$ inch casing.

3d sand of ordinary quality.

Best part of it between 482 feet and 485 feet. This well when first pumped threw off a large quantity of fresh water, and then gradually changed to salt water. The first eight days of pumping the yield of oil did not exceed 3 barrels per day. On the tenth day it produced about 100 barrels of oil, and an equal quantity of salt water. It continued to do the same with but very little variation for four months, after which it slowly declined to 60 barrels of oil, and 60 barrels of salt water. It then declined rapidly to 28 barrels of oil and very little salt water. On the 27th of November, 1872, when the oil flow had declined to 23 barrels, the well was treated with 8 volcanic burners which increased the oil to 30 barrels per day, and also augmented the volume of water. After this, until about June 1st, 1873, the production of oil fluctuated from 22 barrels to 36 barrels per day. It then suddenly declined to 12 barrels per day, with a very perceptible increase of salt water.

Colorado Well, No. 11.

January 20th, 1872.

Level of well mouth above ocean*.....				
Wooden conductor to rock.....	17 feet.	17	=	
?	380	to 397	=	
1st S. S.....	30	" 427	=	
?	117	" 544	=	
2d S. S.....	25	" 569	=	
?	76	" 645	=	
3d S. S.....	46	" 691	=	
? .....pocket.	8½	" 699½	=	

Drilled dry. Cased at 392½ feet.

3d sand good in every part, particularly so between 662 feet and 670 feet.

Natural production 190 barrels daily for five days. Decreased rapidly to 130 barrels, and then more gradually until Sept. 11th, 1872, when it was pumping only 8 barrels. At this time a 3 pint torpedo was put in, 18 feet below the top of the 3d S. S., resulting in a daily production of 150 barrels for three days. It declined rapidly. On Sept. 21st, it had fallen to 24 barrels per day, and on Jan. 1st, 1873, to 4 barrels per day. A 3 pint torpedo was then used 12 feet in the sand, and the yield was thus brought up to 15 barrels per day for a short time.

Then commenced another rapid decline carrying the production down to 3 barrels per day by the 6th of May following, when another torpedo was inserted, resulting in a slight increase of oil.

On June 24th, 1873, while pumping 4 barrels per day, an attempt was made to fill up the well by putting oil and water in at the top. After 275 pails full had been poured in, it was ascertained that it had only filled up the bottom of the 5½ inch well hole 25 feet.

Colorado Well, No. 12.

March, 1872.

Level of well mouth above ocean*.....					1325
Drive pipe to rock.....	57	feet.	57	=	1268
?	198	to	255	=	1070
1st S. S.....	40	"	295	=	1030
?	90	"	385	=	940
2d S. S.....	12	"	397	=	928
?	87	"	484	=	841
3d S. S.....	48	"	532	=	793
? .....pocket.	13	"	545	=	780

Drilled dry. Cased at 220 feet.

* Oil City Depot provisionally 995′ + P. R. R. datum.

Best part of oil sand from 492 feet to 504 feet. Oil came in while running the second "bit" after the 3d sand was struck.*

Natural production 80 barrels per day, when first struck, declining slowly to 7 barrels by the 20th of August, 1872, when a 3 pint torpedo was put in 10 feet below the top of 3d sand. The result was an increase to 60 barrels the first 24 hours and a rapid decline to 10 barrels in 30 days. For two or three months after this it pumped steadily 10 barrels per day, and then began to decline. On May 24th, 1873, it was yielding only 3 barrels per day. Another torpedo was now exploded at a point 14½ feet below the top of the 3d S. S., bringing the production up to 30 barrels per day for two days, followed by a gradual decline to 10 barrels at the end of 30 days.

Colorado Well, No. 13.

July 20th, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.		15	=
?.....	374	to	389	=
1st S. S.....	29	"	418	=
?.....	73	"	491	=
2d S. S.....	19	"	510	=
?.....	98	"	608	=
3d S. S.....	38	"	646	=
Sand and slate alternating.....	8	"	654	=
Slate.....	4	"	658	=

Drilled dry. Cased at 205 feet.

Best sand from 3 to 8 feet below the top of 3d S. S. While drilling in this the well filled up rapidly.

Natural production 3 barrels per day. July 26th, exploded a 3 pint torpedo 5 feet below top of 3d S. S., causing but little improvement in production.

Aug. 2d, 1872, exploded another 3 pint torpedo one foot higher in the sand. Increase slight. Five days after torpedoing the well was producing 5 barrels.

Colorado Well, No. 14.

August 1st, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.		15	=
?.....	372	to	387	=
1st S. S.....	23	"	410	=
?.....	106	"	516	=

* A "bit" is the technical term applied to the chisel-shape tool used in drilling before the "reamer" or finishing tool is introduced. It is seldom "run" more than three feet without being withdrawn for sharpening. Oil struck "while running the second bit" means, therefore, that it was from three to five feet below the top of the sand rock.

2d S. S.		21	to 537	=
?		85	" 622	=
3d S. S.		45	" 667	=
?	pocket.	8	" 675	=

Drilled dry. Cased at 275 feet.

Salt water and gas appeared in 2d S. S. Third sand white and soft. Oil and salt water came in at a point 12 feet below its top. The best quality of sand was between 17 and 25 feet. Soft sand from 28 to 30 feet. Indications of a crevice between 38 and 40 feet.

Natural production 2 barrels per day.

Aug. 10th, 1872. Torpedoed (8 pints) at 18 feet below top of sand. Production rose to 14 barrels per day, but declined in 10 days to 8 barrels. Then sank to 6 barrels. Pumped steadily 6 barrels per day for a long time, then slowly began to decline, and on the 26th of June, 1873, it was pumping less than one barrel per day.

Colorado Well. No. 15.

August 25th, 1872.

Level of well mouth above ocean.....

Wooden conductor to rock		14 feet.	14	=
?		306	to 320	=
1st S. S.		27	" 347	=
?		83	" 430	=
2d S. S.		20	" 450	=
?		97	" 547	=
3d S. S.		38½	" 585½	=
?	pocket.	13½	" 599	=

Drilled dry. Cased at 173 feet.

Considerable gas in 2d S. S.

Softest part of 3d S. S. commenced at 3½ feet below its top, and continued down to 7 feet. At this point there was a large amount of gas and the well filled rapidly with fluid, the larger portion of it being salt water. From 14 to 18 feet below the top of the sand, the composition of the rock was such as to warrant the expectation of a good well, but there was so much fluid in the hole at this time that it could not be positively ascertained whether oil came in at this point or not.

Natural production 1½ barrels per day.

Aug. 29th, 1872. Torpedoed (3 pints) at 5 feet below top of 3d sand. Production first 24 hours thereafter, 12 barrels; and ten days later, 10 barrels per day.

Nov. 18th, 1872. Exploded a torpedo shell filled with giant powder, said to equal in strength a 3 pint nitro-glycerine torpedo. Before torpedoing the well was pumping 5 barrels per day. Four days afterwards, it was producing 6 barrels per day. The explosion filled up the well hole 10 feet. [Meaning, no doubt, with the crushed and broken fragments of the sand rock.]

This well declined very slowly, and on June 24th, 1873, was pumping $1\frac{2}{3}$ barrels per day.

Colorado Well No. 16.

November 6th, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	14 feet.		14	=
?.....	406	to	420	=
1st S. S.....	20	"	440	=
?.....	91	"	531	=
2d S. S.....	19	"	550	=
?.....	107	"	657	=
3d S. S.....	36	"	693	=
?.....pocket.	14	"	707	=

Drilled dry. Cased at $257\frac{1}{2}$ feet.

Very small quantity of gas and salt water in 2d S. S.

Small quantity of salt water came in at the top of 3d S. S. Oil came in from 7 to 10 feet below the top. Sand good down to 14 feet. Good again from 20 to 23 feet. Below 23 feet it was fine and hard, but white, until near the bottom.

Natural production about $\frac{1}{4}$ barrels of oil and 7 barrels of salt water per day.

Nov. 14th, torpedoed (3 pints) 9 feet below top of 3d S. S., it then produced 7 barrels of oil per day for about 10 days.

May 17th, 1873, pumping $1\frac{1}{3}$ barrels per day. Torpedoed 20 feet below top of sand. Increased to 3 barrels per day for a short time.

June 24th, 1873, pumping $1\frac{1}{2}$ barrels per day and continued to do so until Oct. 17th, 1873. Flooded with 7 barrels of Benzine, but slight increase either in gas or oil.

Nov. 16th, 1863, pumping 2 barrels per day.

Colorado Well No. 17.

November 23d, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	13 feet.		13	=
?.....	396	to	409	=
4st S, S.....	21	"	430	=
?.....	101	"	531	=
2d S. S.....	19	"	550	=
?.....	89	"	639	=
3d S. S.....(not through S. S.)	40	"	679	=

Drilled dry. Cased at 237 feet.

Oil came in in small quantities while running the first "bit" in the 3d S. S. First show of salt water about 14 feet below top of sand. Sand soft and white down to 27 feet, then began to change to grey. From 31 feet to 40 feet it was very poor.

Natural production 1½ barrels per day. Torpedoed Dec. 3d, 1872 (3 pints), 14 feet below top of 3d S. S., and 48 hours afterward it was producing at the rate of 10 barrels per day.

The well declined very slowly, and on the 26th of June, 1873, it was still producing 4 barrels per day.

Colorado Well, No. 18.

January 25th, 1873.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.	15	=	
Interval, containing 1st and 2d S. S.....	578	to 593	=	
3d S. S.....	45	" 638	=	
?.....pocket.	11	" 649	=	

Drilled dry. Cased at 275 feet.

But little salt water and no oil came into the well until the drill had penetrated the 3d S. S. about 14 feet, here both oil and salt water came in, filling up the hole 75 feet or more. The best and softest part of the 3d S. S. was from 21 to 28 feet below the top of the rock.

Natural production less than one-half a barrel per day.

Torpedoed February 26, 1873 (3 pints), 14 feet below top of 3d S. S. Production brought up to 2 barrels of oil and 10 or 12 barrels of salt water per day. Pumped about four weeks at this rate, then commenced to increase in oil and decrease in salt water, and in ten days was pumping 24 barrels of oil per day. Pumped at this rate for ten or twelve days, then gradually declined, and four months after torpedoing, was pumping 9 barrels daily.

Colorado Well, No. 19.

February 19th, 1875.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.	15	=	
Interval, containing 1st and 2d S. S.....	514	to 529	=	
3d S. S.....	42	" 571	=	
?.....	9½	" 580½	=	

Drilled dry. Cased at 181 feet.

3d S. S. hard on top but at the depth of 5 feet changed for the better, and some oil and salt water came in. Rock remained quite close until the drill had gone down 13 feet in the sand when it became softer, but still there was no perceptible increase of fluid in the hole. From 13 feet down to 22 feet the sand was rather soft, and remained good down to 33 feet, from which downward it gradually grew finer and harder.

Natural production about 1½ barrels of oil and 12 to 15 barrels of salt water per day.

Feb. 22, 1876, torpedoed (3 pints) 14 feet below top of 3d S. S. After

torpedoing it commenced to pump at the rate of 15 barrels per day, and increased gradually, and on

March 1st, it was pumping 30 barrels per day.
" 20th, " " 34 " "
April 1st, " " 28 " "
" 8th, " " 30 " "
May 10th, " " 20 " "

Colorado Well, No. 20.

April 11th, 1876.

Level of well mouth above ocean.....				
Drive pipe to rock.....	41 feet.	41	=	
Interval, containing 1st and 2d S. S.....	455	to 496	=	
3d S. S.....	44	" 540	=	
?.....pocket.	10	" 550	=	

Drilled dry. Cased at 159 feet.

Softest part of 3d S. S. from 5 to 18 feet below the top. Oil began to come in with a very little salt water while drilling between 5 and 8 feet. Quite an increase of salt water at 24 feet. Gradual increase of gas all the way from 5 to 25 feet. Sand very hard at 39 feet, but good at the bottom of the rock.

Natural production 2½ barrels of oil, with about 8 barrels of salt water per day.

April 21st, 1876, torpedoed (3 pints) 8½ feet below top of 3d S. S. Production during the first twenty-four hours thereafter, 7 barrels of oil with not much increase of salt water and a small increase of gas.

May 10th, 1876, pumping 6 barrels of oil per day.

Colorado Well, No. 21.

June 7th, 1876.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	10 feet.	10	=	
Stove pipe casing*.....	14	" 14	=	
Interval, containing 1st and 2d S. S.....	614	" 628	=	
3d S. S.....	41	" 669	=	
?.....pocket.	10	" 679	=	

Drilled dry. Cased at 249 feet.

The softest and best part of the 3d S. S. commenced at 2 feet below its

* Sometimes the conductor is not properly driven to the rock. The drilling commences, and after going down some distance it is discovered that the loose material is falling in at its bottom. When the "cave" is not very serious a common, riveted, sheet iron "stove pipe" cylinder is shoved down to prevent its enlargement. This casing is merely a supplement or lining to the conductor, and represents what should have been the length of the conductor had it properly been put in originally.

top and continued down to 8 feet. Here oil and gas and salt water came into the hole. The sand was quite soft until the rock had been penetrated 30 feet, after this it was very hard until quite near the bottom, where it was found to be soft and coarse.

Natural production about 5 barrels of oil with 10 barrels of water during the first twenty-four hours. Three days later it was pumping 6 barrels of oil.

June 18th, 1876, pumping about 5½ barrels of oil.

June 20th, 1876, torpedoed (3 pints) 6 feet below top of sand. Result 15 barrels at first, gradually running down to 8½ by Nov. 25th.

Magnolia, No. 1.

Struck June, 1872.

Located on Ware Farm, Colorado District.

Level of well mouth above ocean*.....				
?.....	438	to	438	=
1st S. S.....	30	"	468	=
?.....	122	"	590	=
2d S. S.....	10	"	600	=
?.....	82	"	682	=
3d S. S.....	43	"	725	=
?.....pocket.	10	"	735	=

Drilled dry. Cased at 286 feet.

Show of oil at 688, and gas at 696.

3d S. S. rather dark and close.

Production, after one torpedo, about 2 barrels per day.

Pumped at intervals until January, 1873.

Magnolia, No. 2.

Struck July 7th, 1873.

Ware Farm, Colorado District.

Level of well mouth above ocean*.....					1615
7⅝ inch casing to rock.....	61 feet.		61	=	1554
?.....	691	to	752	=	868
3d S. S.....	42	"	794	=	821
Slate.....	1	"	795	=	820
Very hard shell.....	5	"	800	=	815
?.....pocket.	5	"	805	=	810

Drilled dry. Cased at 350 feet.

Best and softest part of 3d S. S. from near the top down to 12 feet. Good sand all the way down to 30 feet. Oil came in while drilling, but could not tell at what point, on account of the accumulation of salt water in the hole, coming down from the 2d S. S.

Natural production between 3 and 4 barrels per day.

* Oil City Depot, provisionally 995′ + P. R. R. datum.

July 9th, 1873. Torpedoed (3 pints) 7 feet below top of 3 S. S. Produced about 11 barrels the next 24 hours.

July 12th. Torpedoed (3 pints) 12 feet below top of rock. No increase.

Chick Well, No. 1.

January, 1872.

Colorado District.

Level of well mouth above ocean .....

?	598	to	598	=
2d S. S.....	19	"	617	=
?	85	"	702	=
3d S. S.....	34	"	736	=
? .....pocket.	25	"	761	=

"Measured by the drillers; probably incorrect."

Cased with $5\frac{3}{8}''$ casing, but failed to shut off the water. Afterwards cased with $3\frac{1}{4}''$ casing to depth of 450 feet.

3d S. S. about 43 feet thick. Close and dark. Best part of it from 717 to 720 feet. Fair at 734 feet.

Natural production less than one barrel per day.

Torpedoed at 705 feet and $717\frac{1}{2}$ feet. Increased to about 3 barrels per day. The well was pumped by heads, and in January, 1873, produced about 2 barrels per day.

Chick Well, No. 2.

Nov. 15th, 1873.

Colorado District.

Level of well mouth above ocean..... .....

?	0	to	734	=
3d S. S.....	45	"	779	=

Drilled dry. Cased at ———

Mud vein 5 feet below top of 3d S. S. Sand soft at top. Very good between 12 feet and 20 feet. Salt water at 24 feet.

The well filled up with oil about 200 feet before the salt water vein was struck.

Natural production about 10 barrels per day.

Dec. 3d, 1873, torpedoed 13 feet below top of 3d S. S. Production increased to 60 barrels per day. Declined gradually to 15 barrels by Feb. 15th, 1874.

Torpedoed a second time, resulting in a slight increase of oil for a short time.

Chick Well, No. 3.

February 13th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock.....	20 feet.		20	
?	736	to	756	=
3d S. S.....	52	"	808	=
? .....pocket.	14	"	822	=

Drilled dry. Cased at 378 feet.

Strong flow of gas and oil when 3d S. S. was first struck, and the well filled up nearly 300 feet with oil.

Mud vein about 5 feet below top of 3d S. S. Sandrock rather ordinary for the first 25 feet, below that point quite hard, and at the bottom gray and dark. Softer than usual at 17 feet below the top. Salt water appeared between 25 and 30 feet below the top of sand.

Natural production, 75 barrels of oil and 100 barrels of salt water per day.

June 25th, 1873, the production was 25 barrels per day.

Potter Well, No. 1.

February 3d, 1873.

Colorado District.

Level of well mouth above ocean.....			
Wooden conductor to rock.....	25 feet.	25	
?.....	645½ to	670½	=
3d S. S.....	47 "	717½	=
?.....pocket.	12½ "	730	=

Drilled dry. Cased at 266 feet.

3d S. S. good from top to bottom. Soft at 6 feet. Also from 12 to 15 feet, and extra quality at 42 feet. The lower part of the sand was softer than the upper, which is not generally the case in this locality.

The well filled up with fluid nearly 300 feet while drilling, but it was mostly composed of salt water.

Natural production, about 3 barrels of oil and 12 barrels of salt water per day.

Feb. 5th. Torpedoed 12 feet below top of 3d S. S. Bottom of hole filled up one foot with sand. Result, 12 barrels of oil and 50 barrels of salt water per day at first, declining to 6 barrels of oil in four days.

Feb. 10th. Torpedoed 6 feet below top of sand. Well filled up with sand 4 feet. Production slightly increased for a short time.

March 12th. Treated the well with 10 volcanic burners. But slight improvement.

April 2d. Torpedoed 21 feet below top of sand. No benefit.

April 21st, 1873. Abandoned the well.

Potter Well, No. 2.

February 11th, 1873.

Colorado District.

Well mouth above ocean.*.....				1550
Wooden conductor..... ...	15 feet.	15	=	1535
?.....	663 to	678	=	872
3d S. S.....	50 "	728	=	822
?.....pocket.	16 "	744	=	806

Drilled dry. Cased at 264 feet.

* Oil City Depot provisionally 995′ + P. R. R. datum.

The 3d S. S. was good all the way through. Uncommonly so, for the first 20 feet, at which depth there was a good show of oil and gas. Below 25 feet the sand was somewhat harder and finer.

Natural production less than one barrel of oil and 8 or 9 barrels of salt water per day.

Feb. 13th. Torpedoed 20 feet below top of 3d S. S. The well filled up with sand 5 feet. Results, good. An increase both in oil and salt water. After several days' delay in getting the well to work, it pumped when first started up 16 barrels of oil and 100 barrels of salt water per day.

March 18th. Treated it with 10 volcanics. Results, an increase of gas and slight increase of oil.

June 20th, 1873, it was pumping 9 barrels of oil and 18 barrels of salt water.

Potter Well, No. 3.

March 21st, 1873.

Colorado District.

Well mouth above ocean*.....				1549
Wooden conductor to rock	16 feet.	16	=	1533
?.....	661 to	677	=	872
3d S. S.....	50 "	727	=	822
?..... ....pocket.	8 "	735	=	814

Drilled dry. Cased at 270 feet.

The 3d S. S. was good throughout its entire thickness, soft for the first 24 feet, then somewhat harder, but not very hard in any part.

Natural production 2 barrels of oil and 6 or 8 barrels of salt water per day.

April 9th. Torpedoed (3 pint shell), production increased to 15 barrels of oil per day. Sustained the yield at this point for some time and then slowly declined to 8 barrels by the 20th of June following.

Potter Well No. 4.

March 21st, 1873.

Colorado District.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	19 feet.	19		
?.....	637 to	656	=	
3d S. S.....	47 "	703	=	
? ....pocket.	10½ "	713½	=	

Drilled dry. Cased at 255 feet.

3d S. S. very uneven. Upper 13 feet soft, next 3 feet very hard, then 3 or 4 feet of soft sand. Below this finer and more even in composition.

Natural production 1 barrel of oil and 15 or 20 barrels of salt water per day.

March 26th. Torpedoed (3 pint shell) 16 feet below top of 3d S. S. Results, an increase to 4 or 5 barrels of oil and 100 barrels of salt water per

* Oil City Depot provisionally 905′ + P. R. R. datum.

day. Pumped in this way for some time and then gradually increased in oil until it produced 8 barrels per day. A decline then commenced both in oil and salt water. On June 24th, 1873, it had settled back to 5 barrels of oil per day, and on August 6th, to 3 barrels per day. At this time it was torpedoed again, and the next day was pumping at the rate of 8 barrels of oil per day.

On the 21st of August it had run down to 4 barrels per day, with a slight increase in the volume of gas. From this time it gradually declined to 1 barrel per day where it remained for two or three months.

Jan. 22, 1874. Flooded sandrock with benzine with no improvement either to oil or gas.

Jan 28th. Put in one of Quick & Fertig's Injectors.* After the first two injections the production rose to 2½ barrels, increasing to 5 barrels by the end of one week from the time the injector was put in. Benzine was used in the injector; and a gradual increase in production occurred until on July 24th, 1874, the well was pumping 17 barrels of oil per day.

Potter Well, No. 5.

April 4th, 1873.

Colorado District. .

Level of well mouth above ocean.....

Wooden conductor to rock.....	16 feet.		16	=
?.....	655	to	671	=
3d S. S.....	46	"	717	=
?.....pocket.	11	"	728	=

Drilled dry. Cased at .

3d S. S. good. Upper 35 feet white and soft, then 5 feet of gray and the remaining 6 feet white but hard.

Natural production 2 barrels of oil and 8 to 10 barrels of salt water per day.

April 8th. Torpedoed and brought the production up to 140 barrels of oil per day, but it rapidly declined to 16 barrels, and on June 24th had still further declined to 12 barrels per day. It never pumped much salt water.

Potter Well, No. 6.

June 4th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock.....	18 feet.	18	=

* The "injector" is a patented device by which perforations made in the tubing just above the pump chamber can be opened and closed at pleasure by the "sucker rods." Benzine is poured in at the top of the well and the pump kept in motion until the oil in the well and tubing is pumped out and benzine begins to show at the delivery pipe. The tubing is now full of benzine and the well is empty, or nearly so. On opening the apparatus in the injector, the 500 or 1000 feet of benzine in the tubing forces out strong jets in all directions against the walls of the well washing them down with force and giving more satisfactory results than can be obtained by a simple "flooding" with benzine. The process may be repeated again and again until the desired effect is produced.

?		639	to 657	=
3d S. S.		46	" 703	=
?	pocket.	12	" 715	=

Drilled dry. Cased at 240 feet.

3d S. S. good to the depth of 32 feet, below that, finer and not so white.

Oil came in near top of the sand and salt water 4 feet below the top.

Natural production 2 barrels of oil with 6 or 8 barrels of salt water per day.

June 6th. Torpedoed and increased the production to 150 barrels of oil daily. Declined in fourteen days to 36 barrels daily.

June 28th, 1875. Torpedoed 6 feet below top of 3d S. S. Result $3\frac{1}{3}$ barrels per day.

Potter Well, No. 7.

July 11th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock		16 feet.	16	=
?		629	to 645	=
3d S. S.		46	" 691	=
?	pocket.	13	" 704	=

Drilled dry. Cased at 229 feet.

3d S. S. very soft the first 12 feet, soft the next 14 feet and then harder and not so good as the drill approached the bottom. The well filled up with oil very fast after the sand was struck and while the first "bit" was being run in it.

Natural production 8 barrels per day.

July 14. Torpedoed (3 pint shell) $6\frac{1}{2}$ feet below top of 3d S. S. Result, a production of 100 barrels of oil per day.

Nov. 20th, 1874. Production down to $\frac{2}{3}$ of a barrel per day. Torpedoed (giant powder) $7\frac{1}{2}$ feet below top of sand. No increase in gas and very little in oil.

From July, 1876, until the 11th of October following, this well produced 2 barrels per day, and then, without any treatment whatever, began to increase. On Oct. 25th it was producing $5\frac{1}{3}$ barrels, Nov. 10th, $6\frac{2}{3}$ barrels, and Nov. 25th, $5\frac{1}{2}$ barrels.

Potter Well, No. 8.

April 27th, 1876.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock		15 feet.	15	=
?		616	to 631	=
3d S. S.		47	" 678	=
?	pocket.	10	" 688	=

Drilled dry. Cased at 225 feet.

3d S. S. first 4 feet very hard, next 8 feet very soft; then 9 feet a little firmer but not hard; then 10 feet softer; the remaining 16 feet being about an average sand. The first show of oil was at 21 feet below the top of the sand. Very little salt water and gas came into the hole while drilling, and when the well was tubed there was not more than 20 feet of fluid in it.

Natural production less than $\frac{1}{4}$ of a barrel of oil with about 5 barrels of salt water per day.

The first torpedo exploded 18 feet below top of sand increased the salt water slightly but not the oil and gas.

May 8th. Second torpedo (3 pint shell) 6 feet below top of sand. No improvement.

May 11th. Employed the scratcher. No improvement.

May 12th. Torpedoed 30 feet below top of sand. No increase either in oil or gas.

June 6th. Put in Quick & Fertig's injector. Still no improvement.

The well was abandoned June 22d, 1876, after having been pumped steadily for nearly two months.

Darling Well.

Drilled in 1865.

Gilson Run, Warren County.

Level of well mouth above ocean.....		
Drive pipe.....		57½ feet.
Soft slate.....	at	70 "
Very hard slate and 3 inch crevice.....	"	78 "
20 inch of salt water.....	"	145 "
Soft slate, 15 inch crevice.....	"	175 "
Very fine sandrock.....	"	185 "
12 inch crevice.....	"	230 "
Some oil, 15 inch crevice.....	"	290 "
Bottom of sandrock.....	"	310 "
Grey sandrock.....	"	355 "
Water course carrying away everything from the well.....	"	373 "
Some oil, 15 inch crevice.....	"	399 "
Fine white sand.....	"	411 "
Bottom of Sand.....	"	426 "
Flint and slate.....	"	450 "
Top of sandrock.....	"	514 "
Coarse white pebble sand, 6 inch crevice.....	"	522 "
Pebble rock and bottom of well.....	"	541 "

This well was never cased. The water was shut off by seed bag on tubing. It was pumped some time, producing several barrels of oil which is supposed to have come from the 2d S. S.

Clifton Well, No. 1

April, 1872.

Colorado District, southeast corner of tract 200.

Level of well mouth above ocean .....

?	0	to	402	=
1st S. S., (estimated)	20	"	422	=
?	123	"	545	=
2d S. S.	19	"	564	=
?	84	"	648	=
3d S. S.	42	"	690	=

Drilled dry. Cased at 264 feet.

Very poor sand. Well never tubed.

Eclipse Wells.

Colorado District.

Level of well mouth above ocean.....

6¼ inch casing to rock	48 feet.		48	=
Mountain sand	162	to	210	=
?	240	"	450	=
1st S. S. (estimated)	20	"	470	=
?	55	"	525	=
2d S. S. (estimated)	10	"	535	=
?	45	"	580	=
3d S. S. (estimated)	20	"	600	=
?	76	"	676	=
4th S. S.	29	"	705	=
? .....pocket.	12	"	717	=

Cadwell Well.

Hill Farm, Colorado District.

Level of well mouth above ocean.....

6¼ inch casing to rock	36	to	36	=
?	280	"	266	=
1st S. S.	29	"	295	=
?	105	"	400	=
2d S. S.	18	"	418	=
?	83	"	501	=
3d S. S.	46	"	547	=
? .....pocket.	4	"	551	=

Wet hole. Cased (3¼ inch) at 275 feet.

Abandoned Dec. 30th, 1875.

Onondaga Well.

East of Enterprise; Colorado District.

Level of well mouth above ocean.....

Drive pipe	62 feet.		62	=

?	137	to	199	=
S. S. gray	25 ?)	"	224	=
?	236	"	455	=
2d S. S.	15	"	470	=
?	51	"	521	=
3d S. S.	13	"	534	=
?	36	"	570	=
4th S. S.	15	"	585	=
?	90	"	675	=
5th S. S.	26	"	701	=
Soft measures. No sandstone	99	"	800	=

Enterprise, Warren County.

Benedict Estate Wells, copied from office records.

Benedict Estate Well, No. 1.

Level of well mouth above ocean.....

?	192	to	192	=
1st S. S.	50	"	242	=
?	58	"	300	=
2d S. S.	4	"	304	=
?	31	"	335	=
3d S. S.	10	"	345	=
?	117	"	462	=
4th S. S.	15	"	477	=

Willard Well, No. 1.

Level of well mouth above ocean.....

Upper measures not noted	443	to	443	=
3d S. S.	25	"	468	=

Harvey Well, No. 1.

Level of well mouth above ocean.....

?	180	feet.	180	=
1st S. S.	49	to	229	=
?	71	"	300	=
2d S. S.	6	"	306	=
?	16	"	322	=
3d S. S.	12	"	334	=
?	95	"	429	=
4th S. S.	6	"	435	=
?	14	"	449	=
5th S. S., oil	15	"	464	=

McKinney Well, No. 1.

Level of well mouth above ocean.....

Upper measures not noted	441	to	441	=
3d S. S.	21	"	462	=

Reed Well.

Adjoining Benedict Estate. Record from memory of driller.

Level of well mouth above ocean.....				
?.....	150 feet.		150	=
1st S. S.....	52	to	202	=
Slate, blue.....	118	"	320	=
2d S. S.....	14	"	334	=
S. S., hard, gray.....	12	"	346	=
Slate, black.....	99	"	445	=
Stray S. S., gray.....	12	"	457	=
Slate.....	12	"	469	=
3d S. S.....[doubtful whether 12 or 22]	22	"	491?	=

Tidioute and Warren Oil Co.

Dennis Run between Triumph and Tidioute.
Records furnished by Major Cushing, of Tidioute.

Lease No. 58. *Well No.* 1.

Well mouth above ocean*.....				(?)	1230
?.....	45	to	45	=	1185
1st S. S.....	30 (?)	"	75?	=	1155
?.....	62	"	137	=	1093
2d S. S.....	25 (?)	"	162?	=	1068
?.....	133	"	295	=	935
Stray S. S.....	47	"	342	=	888
?.....pocket.	8	"	350	=	880
Depth of well.....					

Well No. 2.

Level of well mouth above ocean.....				
?.....	124	to	124	=
1st S. S.....	29	"	153	=
?.....	63	"	216	=
2d S. S.....	28	"	244	=
?.....	26	"	270	=
Stray S. S.....	16	"	286	=
?.....	90	"	376	=
3d S. S.....	48	"	424	=

Well No. 3.

Level of well mouth above ocean.....				
?.....	180	to	180	=
1st S. S.....	30	"	210	=
?.....	60	"	270	=
2d S. S.....	35	"	305	=
?.....	35	"	340	=

* Oil City Depot provisionally 995′ + P. R. R. Datum.

Stray S. S.	25	to	365	=
?	60	"	425	=
3d S. S.	50	"	475	=

At 436 first show of oil ; at 445 second show of oil.

Well No. 4.

Level of well mouth above ocean.....

?	320	to	320	=
1st S. S.	35	"	355	=
?	55	"	410	=
2d S. S.	35	"	445	=
?	27	"	472	=
Stray S. S.	13	"	485	=
?	82	"	567	=
3d S. S.	27	"	594	=

Well No. 5.

Level of well mouth above ocean.....

?	332	to	332	=
1st S. S.	47	"	379	=
?	44	"	423	=
2d S. S.	35	"	458	=
?	29	"	487	=
Stray S. S.	13	"	500	=
?	84	"	584	=
3d S. S.	48	"	632	=

Triumph Oil Co.

Triumph, Warren Co. From books in office of Company.

Well No. 23.

Level of well mouth above ocean.....

?		660	to	660	=
3d S. S. 79 feet.	Fine hard sand	30	"	690	=
	Medium "	13	"	703	=
	Good "	17	"	720	=
	Pebble, (crevice at 722½)	10	"	730	=
	Good sand	9	"	739	=

Well No. 101.

Level of well mouth above ocean.....

?	662	to	662	=
3d S. S.	88	"	750	=
? pocket.	6	"	756	=

Sand very good.

Well No. 146.

Level of well mouth above ocean.....

?			694	to 694	=
3d S. S.			96	" 790	=

Coarsest from 764 to 774.
Salt Water at 773.

Well No. 148.

Level of well mouth above ocean.....

?			712	to 712	=
3d S. S.			103	" 815	=

Coarsest sand at 795 feet.
Mud at 732, 765 and 785.

Well No. 149.

On highest point of hill.

Level of well mouth above ocean.....

?			729	to 729	=
3d S. S. 74 feet.	Pebble		2	" 731	=
	Coarse sand		1	" 732	=
	Medium "		2	" 734	=
	Pebble		20	" 754	=
	Coarse sand		10	" 764	=
	Pebble		20	" 784	=
	Coarse sand		12	" 796	=
	Pebble		4	" 800	=
Medium sand			3	" 803	=
?		pocket.	6	" 809	=

Well No. 152. *B.*

Level of well mouth above ocean.....

?			712	to 712	=
3d S. S.			90	" 802	=
?		pocket.	3	" 805	=

Upper 60 feet fine.
Lower 30 feet coarse.

Well No. 224.

Level of well mouth above ocean.....

?			675	to 675	=
3d S. S.			107	" 782	=
?		pocket.	3	" 785	=

Good sand at 759.
Pebble at 782.

Well No. 237.

Level of well mouth above ocean.....

?		667	to	667	=
3d S. S. 106 feet.	Fine sand	56	"	723	=
	Very coarse pebble	20	"	743	=
	Fine sand	10	"	753	=
	Grayish pebble	20	"	773	=
? pocket.		3	"	776	=

Mud at 701 and 710.
Salt water at 747.

Rising Sun Well.

Dennis Run. From S. Minor.
Level of well mouth above ocean.....

?	104	to	104	=
1st S. S.	30	"	134	=
?	61	"	195	=
2d S. S.	28	"	223	=
?	117	"	340	=
3d S. S.	28	"	368	=

There was a gray rock about 20 feet below the 2d S. S., and sometimes 25 feet thick. All the rocks were very hard.

Dennis Run.

Wells of J. & E. W. Parshall on tract of N. Y. and Allegheny Oil Co., Dennis Run, near Tidioute. Furnished by Mr. Parshall.

Well No. 4.

Level of well mouth above ocean.....

?	320	to	320	=
1st S. S., estimated	30	"	350	=
? (including 2 S. S.)	230	"	580	=
3d S. S.	36	"	616	=
? pocket.	5	"	621	=

Well No. 5.

Level of well mouth above ocean.....

?	330	to	330	=
1st S. S., estimated	30	"	360	=
? including 2d S. S.	230	"	590	=
3d S. S.	40	"	630	=

Well No. 7.

Level of well mouth above ocean.....

?	240	to	240	=
1st S. S., estimated	30	"	270	=
? including 2d S. S.	222	"	492	=

3d S. S.		50	to 542	=
?	pocket.	5	" 547	=

Well No. 9.

Level of well mouth above ocean				
?	including 1st S. S.	301	to 301	=
2d S. S., estimated		25	" 326	=
?		115	" 441	=
3d S. S.		66	" 507	=
?	pocket.	6	" 513	=

Well No. 10.

Level of well mouth above ocean				
?		224	to 224	=
1st S. S., estimated		30	" 254	=
?	including 2d S. S.	208	" 462	=
3d S. S.		69	" 531	=
?	pocket.	23	" 554	=

Well No. 12.

Level of well mouth above ocean				
?		255	to 255	=
1st S. S., estimated		30	" 285	=
?	including 2d S. S.	233	" 518	=
3d S. S.		82	" 600	=
?	pocket.	20	" 620	=

Dennis Run Tract. E. W. Parshall's Wells.

Well No. 1.

Level of well mouth above ocean				
?		110	to 110	=
Mountain S. S.		37	" 147	=
?		151	" 298	=
1st S. S.		43	" 341	=
?		89	" 430	=
2d S. S.		30	" 460	=
?		91	" 551	=
3d S. S.		36	" 587	=
?		15	" 602	=

Well No. 2.

Level of well mouth above ocean				
?		73	to 73	=
Mountain S. S., estimated		35	" 108	=
?		153	" 261	=

1st S. S., estimated	40	to	301	=
?	88	"	389	=
2d S. S., estimated	30	"	419	=
?	95	"	514	=
3d S. S	50	"	564	=

Well No. 3.

Level of well mouth above ocean				
?.....including Mountain S. S.	274	to	274	=
1st S. S	32	"	306	=
?.....including 2d S. S.	221	"	527	=
3d S. S	50	"	577	

Richardson, Tidioute. East side of Allegheny River. From Messrs. Rallston & Harrington.

Well No. 1.

Situated half way down the hill.				
Level of well mouth above ocean				
?	84	to	84	=
1st S. S	24	"	108	=
?	29	"	137	=
2d S. S	23	"	160	
?	76	"	236	=
3d S. S	9	"	245	=

Well No. 2.

Up the hill.				
Level of well mouth above ocean				
?	310	to	310	=
1st S. S	20	"	330	=
?	24	"	354	=
2d S. S	24	"	378	=
?	71	"	449	=
3d S. S	11	"	460	=

NOTES.

In drilling an oil well, the measures passed through are necessarily divided into three groups or divisions. Each one of these divisions requires a specific treatment at the hands of the driller.

The first division is composed of Drift or the loose surface accumulations from the surrounding rocks; the second embraces the immediately underlying series of stratified rocks to the depth at which they contain water; and the third, the remainder of the well, including the oil sands at the bottom. The walls of the third division are generally self-supporting, remaining just as the drill leaves them, and this division, when the well is completed, is the only one where the rocky walls are bare.

The first division, owing to the loose and crumbling material of which it is composed, requires some mechanical device to prevent it from slipping or caving into the hole as it is drilled. Here the "conductor" is used A "conductor" may be simply a long box, without ends, made by spiking together four planks 2″ thick by 10″ wide—a "wooden conductor;" or it may be "drive pipe," composed of a number of cast-iron cylinders joined together and driven through the deposit; or it may be what is now more generally used, wrought-iron "surface casing," put in in a somewhat similar manner.

The "wooden conductor" can only be economically used where the surface deposit is of inconsiderable depth, as a pit must be sunk to the rock before it can be put in place. After the rock has been laid bare by the pick and shovel, the "conductor" is securely set between it and the derrick floor, the drill is let down to the rock through the conductor and the work of boring commences.

Where it is suspected that the floor of the Drift lies too deep to be reached by digging, cast-iron "drive pipe" is used. This pipe is cast in sections about 9′ long. A space of 4″ at each end is carefully turned in a lathe to a certain gauge, and the end is cut smoothly at right angles to the axis of the pipe, so that the joints will stand perpendicularly one upon the other. A joint of pipe is placed on end in the centre of the derrick between two "guides" which have been temporarily erected for the purpose of driving it. A heavy "mall" working between these guides is raised and dropped upon the pipe, slowly forcing it into the ground, precisely as piles are driven for docks, bridges, &c. When the top of a joint has been driven to the level of the derrick floor, a band of wrought-iron, made to fit the turned ends of the pipes and heated red-hot, is quickly slipped upon the end of the driven pipe and another joint at once set up. The contraction of this band in cooling holds the two joints firmly together and the driving process then goes on. In this way joint after joint is added and driven until solid rock is reached. As many as 23 joints have been used in a well. Great care is required when so long a "string of pipe" is driven to keep it straight and perpendicular, a broken band, or a large boulder encountered may cause the pipe to so far deviate from the perpendicular as to necessitate the abandonment of the well. To avoid this the pipe should be frequently cleaned out by the drill while being driven.

The more common method now employed in driving the well shafts through these thick accumulations of loose materials, is to use heavy wrought-iron casing, made expressly for the purpose and armed with a hardened collar or "shoe," at the bottom. This casing is made in joints about 20′ in length, which screw together in wrought-iron "thimbles," the same as do ordinary gas pipes. The tube being thin and light as compared with cast-iron drive pipe, cannot be so forcibly driven, but is worked down carefully by drilling a hole the full size of its inside diameter, and always keeping this hole open some feet in advance of the bottom of the pipe. In

(*Continued on page* 378.)

Columbia Farm (Old Story Farm,) on Oil Creek, one mile below Petroleum

Name of Well.	Depth of Conductor.	Rock Interval.	First Sand. Top.		Bottom.	Rock Interval.	Second Sand. Top.		Bottom.
Babcock..	36	304	340	50	390	52	442	25	467
Stewart...	18	276	294	39	333	103	436	26	462
Reiter	18	399	417	47	464	74	538	25	563
Jones.	27	292	319	37	356	105	461	24	485
Blocher ..	30	207	237	28	265	105	370	23	393
No. 58..	27	313	340	33	373	72	445	36	481
" 59..	18	282	300	19	319	124	443	21	464
" 61..	21	458	479	21	500	101	601	23	624
" 62..	27	270	497	32	529	73	602	34	636
" 64..	27	498	525	30	555	82	637	33	670
" 66..	18	518	536	31	567	101	668	23	691
" 69..	24	528	552	27	579	85	664	31	695
" 70..	24	146	170	29	199	111	310	27	337
" 71..	27	502	529	44	573	107	680	20	700
" 72..	18	272	290	35	325	105	430	40	470
" 73..	18	262	280	35	315	102	417	18	435
" 74..	18	257	275	30	305	105	410	27	437
" 77..	36	483	519	42	561	97	658	22	680
" 78..	18	487	505	25	530	123	653	22	675
" 80..	27	525	552	35	587	107	694	24	718
" 81..	18	322	340	45	385	100	485	30	515
" 82..	18	312	330	40	370	115	485	25	510
" 85..	27	258	285	55	340	95	435	20	455
" 86..	36	304	340	50	390	85	475	25	500
" 87..	45	315	360	32	392	98	490	24	514
" 89..	18	262	280	30	310	135	445	24	469
" 90..	18	287	305	50	355	105	460	20	480
" 91..	18	269	287	57	344	115	459	22	481
" 94..	54	171	225	20	245	120	365	33	398
" 96..	18	382	400	40	440	85	525	39	564
" 97..	45	290	335	50	385	103	488	20	508
" 99..	27	508	535	45	580	105	685	20	705
" 100..	27	375	402	53	455	84	539	15	554
" 101..	26	354	380	50	430	101	531	24	555
" 103..	27	283	310	40	350	90	440	41	481
" 104..	27	438	465	50	515	92	607	24	631
" 105..	18	339	357	53	410	90	500	27	527
" 106..	27	482	509	50	559	100	659	25	684
" 107..	27	281	308	40	348	102	450	26	476
" 108..	18	527	545	31	576	103	679	72	751
" 109..	9	521	530	40	570	110	680	30	710

Centre, Venango Co. Pa. From the books of the Columbia Oil Company.

Rock Interval.	Stray Sand. Top.		Bottom.	Rock Interval.	Third Sand. Top.		Bottom.	Pocket.	Feet Depth.
76	543	30	573	20	593	50	643	10	653
58	520	30	550	21	571	53	624	3	627
49	612	30	642	20	662	54	716	6	722
68	553	30	583	20	603	51	654	3	657
76	469	31	500	10	510	52	562	8	570
39	520	32	552	20	572	43	615	3	618
46	510	30	540	19	559	53	612	6	618
53	677	33	710	21	731	49	780	15	795
44	680	30	710	19	729	41	770	11	781
53	723	30	753	17	770	40	810	0	810
63	754	32	786	18	804	46	850	0	850
52	747	34	718	12	793	39	832	5	837
60	397	33	430	17	447	45	492	3	495
54	754	30	784	21	805	40	845	5	850
37	507	25	532	30	562	42	604	0	604
74	509	33	542	14	556	50	606	0	606
69	506	30	536	15	551	37	588	7	595
78	758	28	786	12	798	45	843	0	843
54	729	31	760	15	775	40	815	6	821
67	785	27	812	18	830	36	866	2	868
53	568	31	599	19	618	34	652	3	655
40	550	33	583	17	600	38	638	3	641
45	500	33	533	22	555	40	595	3	598
51	551	29	580	20	600	45	645	3	648
54	568	30	598	21	618	50	668	3	671
46	515	31	546	20	566	39	605	5	610
53	533	26	559	15	574	38	612	3	615
64	545	29	574	12	586	37	623	4	627
49	447	33	480	20	500	40	540	5	545
52	616	27	643	12	655	33	688	2	690
50	558	30	588	22	610	50	660	5	665
52	757	28	785	24	809	41	850	3	853
73	627	30	657	18	675	50	725	2	727
63	618	33	651	17	668	30	698	3	701
71	552	21	573	17	590	50	640	2	642
60	691	26	717	19	736	50	786	5	791
45	572	30	602	35	637	40	677	1	678
53	737	30	767	17	784	50	834	5	839
64	540	29	569	16	585	54	639	3	642
33	784	27	811	13	824	44	868	2	870
65	775	27	802	13	815	39	854	1	855

Name of Well.	Depth of Conductor.	Rock Interval.	First Sand.			Rock Interval.	Second Sand.		
			Top.		Bottom.		Top.		Bottom.
No. 110..	36	464	500	37	537	143	680	20	700
" 111..	18	350	368	47	415	92	507	55	562
" 112..	27	313	340	35	375	80	455	35	490
" 113..	18	417	435	50	485	97	582	18	600
" 114..	27	405	432	72	504	72	576	24	600
" 115..	27	308	335	37	372	100	472	25	497
" 116..	27	445	472	38	510	108	618	21	639
" 117..	9	206	215	40	255	94	349	20	369
" 118..	18	517	535	32	567	99	666	25	691
" 119..	18	304	322	18	340	125	465	20	485
" 120..	18	492	510	30	540	102	642	23	665
" 121..	30	143	173	29	202	111	313	27	340
" 122..	36	134	170	40	210	90	300	35	335
" 123..	14	346	360	45	405	110	515	25	540
" 124..	16	294	310	30	340	135	475	25	500
" 125..	30	304	334	38	372	97	469	23	492
" 126..	15	441	456	20	476	124	600	24	624
" 127..	18	410	428	20	448	102	550	24	574
" 128..	18	312	330	56	386	100	486	25	511
" 129..	27	235	262	35	297	102	399	28	427
" 130..	20	286	306	41	347	100	447	28	475
" 131..	18	507	525	40	565	100	665	24	689
" 132..	16	217	233	30	263	110	373	24	397
" 133..	26	169	195	45	240	105	345	20	365
" 134..	13	470	483	39	522	98	620	35	655
" 135..	28	469	497	30	527	102	629	29	658
" 136..	13	417	430	71	501	72	573	23	596
" 137..	11	349	360	40	400	100	500	26	526
" 138..	14	366	380	45	425	95	520	22	542
" 139..	36	306	342	39	381	99	480	28	508

(*Continued from page* 375.)

the old filled up valley of the Tunauquant, at Tarport, McKean Co. Pa. from 200′ to 300′ of this casing is required in each well.

Wells are spoken of indiscriminately as "small holes" or "wet holes" on the one hand, and as "cased holes" or "dry holes" on the other. A "small hole" must necessarily be a "wet" one, for there is no room to case off the water while drilling; and a "cased hole" must necessarily be a "dry" one, if the casing accomplishes the purpose for which it is used.

If now a well is to be drilled "wet," that is if no effort is to be made to shut off the water which comes into it from the second division mentioned above, to keep it from following the drill down to the oil rocks, then

Rock Interval.	Stray Sand. Top.		Bottom.	Rock Interval.	Third Sand. Top.		Bottom.	Pocket.	Feet Depth.
50	750	30	780	20	800	35	835	2	837
18	580	33	613	19	632	52	684	5	689
53	543	29	572	10	582	43	625	3	628
55	655	32	687	18	705	35	740	3	743
62	662	30	692	18	710	48	758	2	760
60	557	29	586	19	605	52	657	7	664
91	730	31	761	*	750	41	791	2	793
64	433	33	466	18	484	52	536	5	541
62	753	33	786	17	803	45	848	5	853
53	538	30	568	12	580	55	635	5	640
66	731	27	758	20	778	47	825	5	830
61	401	33	434	22	456	45	501	2	503
58	393	31	424	18	442	43	485	2	487
61	601	29	630	20	650	45	695	5	700
85	585	26	611	14	625	38	663	0	663
72	564	22	586	20	606	47	653	2	655
44	668	29	697	18	715	53	768	3	771
53	627	31	658	20	678	54	732	2	734
47	558	27	585	18	603	37	640	5	645
73	500	26	526	12	538	45	583	5	588
77	552	24	576	14	590	40	630	2	632
63	752	28	780	20	800	41	841	3	844
61	458	32	490	17	507	35	542	30	572
64	429	33	462	17	479	38	517	20	537
45	700	35	735	25	760	50	810	5	815
62	720	32	752	15	767	40	807	8	815
64	660	28	688	17	705	45	750	10	760
80	606	26	632	*	630	55	685	5	690
81	623	30	653	*	650	52	702	5	707
43	551	29	580	34	614	44	658	5	663

this "conductor" of which we have been speaking, whether of wood, cast-iron or casing, needs only to be 6″ in diameter, inside measurement. But if the well is to be drilled "dry," an 8″ conductor must be used, as will be seen further on.

In the first case (for a wet well), after the conductor is in place, a plain 5½″ hole is drilled all the way to the oil rocks; the water, meantime, nearly filling the well, or perhaps overflowing at the top of the conductor.

In the latter case (for a dry hole), an 8″ hole is to be drilled from the bottom of the conductor to a point below the water veins. When this is

* These are evidently errors in Nos. 116, 137 and 138 as the bottom of the Stray S. S. as here given overlaps upon the 3d S. S.

done, a 5⅝″ casing (inside diameter) is inserted, with a device on the bottom so arranged that it will form a water tight joint between the casing and wall of the well. A 5½′ hole is then continued down to the oil rocks from the inside of this last "string of casing." If the casing has been inserted to the proper depth and no water is encountered below it, the sand-pump will soon exhaust the water in the process of drilling, and the well be perfectly dry. But if lower veins of water are struck, the casing must be drawn, the hole reamed out to a greater depth, and the casing continued down below them. After the water is exhausted, a few pails full are poured in as circumstances demand; to moisten the drillings and furnish fluid for the sand-pump.

Comparing now the two wells when completed and ready for the pump, we find them both to be of the same size, 5½″ in diameter. One has simply a conductor through the upper division, all the stratified rocks being bare, is full of water, and has probably shown but very little indication of oil. The other has a conductor through the upper division, casing inside of this to the bottom of the middle division, and is dry—or at least was dry until the striking of the oil sand, when it immediately filled up several hundred feet with oil, or perhaps flowed.

The "dry" well is ready at once for the introduction of the pump tube; the "wet" one must be cased before it is tubed. The casing used for this purpose ("small casing,") is of 3¼″ inside diameter. A "water packer" or "seed bag" is attached to its lower end, which effectually closes the annular space between the outside of the casing and wall of the well. This "small casing," of course, must extend down to the bottom of the second division, the same as the large casing does in the "dry" well, for it has precisely the same duty to perform, the shutting off of the water in the upper rocks from the well shaft.

The well is now tubed with the ordinary 2″ "tubing," having a "working barrel" or pump chamber at the bottom, which is placed at or near the point where the oil enters.

Inside of the "tubing" are inserted the "sucker rods" which are connected in the derrick to the "walking beam," and operate the pump valves below.

Upon starting the pump, the "water packer" prevents any of the fluid outside of the casing from entering the well, and the water inside of the casing and in the uncased portion of the well is soon pumped out and the well is said to be "exhausted." As the well exhausts, the oil, which has been held back in the rock by the pressure of the heavy column of water above it, gradually forces its way into the well and is raised by the pump to the surface, unless it has a sufficient force of gas to flow of its own accord afterwards.

Stated Meeting, January 5th, 1877.

Present 15 Members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the Academy at Lisbon, Aug. 24 (XV 2; 94, 95), and the Meteorological Office, London, December 1, 1876 (97).

Letters of envoy were received from the Italian Society of Sciences at (Modena) Rome, and the Society at Liverpool, November 25th, 1876.

Donations for the Library were received from the R. S. New S. Wales; the Academies at St. Petersburg, Berlin and Philadelphia; the Societies at Königsburg and Boston; the Institute of Lombardy; Soc. Ital. d. Sci. at Rome; R. Geol. Committee at Rome; S. Capellini; Nouv. Mét. and Rev. Pol. Paris; Astron. and Antiq. SS and London Nature; Franklin Institute; Coll. of Pharmacy; Smith. Institution, Dr. Hayden, and the Brazilian Government.

No. 96 of the Proceedings just published was laid on the table for examination.

The death of Dr. Jos. Carson, at Philadelphia, Dec. 30, 1876, in the 69th year of his age, was announced by Mr. Fraley; and on motion Dr. John B. Biddle was appointed to prepare an obituary notice of the deceased.

Mr. Chase made a communication "On the influence of central forces in determining chemical volumes."

Mr. Britton exhibited specimens of artificial fuel manufactured from the peat bogs near Syracuse, in New York, and remarked upon its resemblance to the lignite of S. W. Arkansas, promising a further description.

Mr. Briggs communicated a paper "On Refraction Tables," by Prof. A. K. Mansfield, of Cordova, S. A.

Dr. LeConte communicated notes and a table to point out the most important features of the memoir published in No. 96 of the Proceedings.

Mr. Lesley read characteristic portions of a paper by Mr. Leo Lesquereaux of Columbus, introductory to "The Flora of the Carboniferous of North America," which he is preparing as one of the Reports of Progress of the Second Geological Survey of Pennsylvania.

The report of the judges and clerks of the annual election was read, announcing the following list of officers for the ensuing year:

President.

George B. Wood.

Vice-Presidents.

Frederick Fraley, Eli K. Price, E. Otis Kendall.

Secretaries.

John L. LeConte, Pliny E. Chase, George F. Barker,
J. Peter Lesley.

Curators.

Hector Tyndale, Charles M. Cresson, Daniel G. Brinton.

Treasurer.

J. Sergeant Price.

Councillors.

Isaac Hays, Robert E. Rogers, Henry C. Carey,
Robert Bridges.

Mr. Lesley was nominated Librarian.

Pending nominations 809 to 829 were read.

On motion the Librarian was authorized to transmit to the Deputy Secretary of the Commonwealth at Harrisburg, for publication in the new volume of Archives, the MSS. Journal of Col. Burd at Fort Augusta, in 1763, taking the needful guarantees for the safety and return of the MSS. to the Library of the Society.

And the meeting was adjourned.

Stated Meeting, January 19th, 1877.

Present, 19 members.

Vice-President, Mr. PRICE, in the Chair.

A letter of envoy was received from the Imp. Botanical Gardens of St. Petersburg, Aug. 15, 1876.

Donations for the Library were received from the Mining Bureau at Melbourne; R. Acad. at Turin; S.Vin. Fiorentino of Naples; the Ulm Art Union; R. Acad. at Brussels; Rev. Pol. and Nature; Cobden Club; Canadian J. of Science, Toronto; Essex Institute; S. N. H. Boston; S. C. E. Boston; Hon. W. W. Crapo, of New Bedford; Sill. Journal; Amer. Chemist; Med. News; A. J. Med. Sciences; Penn Monthly; Franklin Institute; Geol. Survey of Pa; E. D. Cope; Ordnance Department U. S. A., and Corps of Engineers.

No. 98 of the Proceedings just published was laid on the table for the inspection of the members.

The Secretary presented a communication entitled: On the first systematic collection and discussion of the Venango Co. oil wells of Western Pennsylvania, by E. S. Nettleton, C. E., prepared for publication and communicated by J. F. Carll, Asst. Geol. Sur. Pa. in charge of the Survey of the Oil Regions.

Gen. Kane read a description of his recent explorations in Coahuila, Mexico, exhibiting photographs of Mexican soldiers, and describing the movement of the Indian population southward still going on.

Dr. König described his success in establishing a scale of colorimetry for minerals containing titanic acid, &c. and explained his processes.

Mr. Blodget brought to the notice of the Society the text of a proposed Act of Congress ordering a new Arctic expe-

dition, the discussion of which was postponed to the next meeting: viz—

And be it further enacted, That the President of the United States be authorized to organize and send out one or more expeditions toward the North Pole, and to establish a temporary colony, for purposes of exploration, at some point north of the eighty-first degree of north latitude on or near the shore of Lady Franklin Bay; to detail such officers or other persons of the public service to take part in the same as may be necessary, and to use any public vessel that may be suitable for the purpose; the scientific operations of the expedition to be prosecuted in accordance with the advice of the National Academy of Science, and that the sum of fifty thousand dollars, or such part thereof as may be necessary, be hereby appropriated out of any moneys in the Treasury not otherwise appropriated, to be expended under the direction of the President. *Provided*, That no part of the sum so appropriated shall be carried to the surplus fund or covered into the Treasury until the purpose of the appropriation shall have been completed, but may be applied to expenses of said expedition incurred during any subsequent year that said expedition may be engaged in its duties.

On motion, Mr. Lesley was elected Librarian for the ensuing year.

The following nominations were made and on motion adopted:

Standing Committees for 1877:

Finance.

Mr. Frederick Fraley,
Mr. E. K. Price,
Mr. Benjamin V. Marsh.

Publication.

Dr. John L. LeConte,
Dr. Daniel M. Brinton,
Mr. W. M. Tilghman,
Dr. Harrison Allen,
Dr. C. M. Cresson.

Hall.

Gen. Hector Tyndale,
Mr. Edward Hopper,
Mr. S. W. Roberts.

Library.

Mr. Eli K. Price,
Rev. Charles T. Krauth,
Dr. George H. Horn,
Dr. Kinderdine,
Prof. Houston.

The reading of the list of surviving members was postponed.

The election of new members was postponed to the next meeting.

And the meeting was adjourned.

Stated Meeting, February 2nd, 1877.

Present, 24 members.

Vice-President, Mr. E. K. Price, in the Chair.

The photograph of Mr. Daniel B. Smith was received for insertion in the album.

A letter accepting his appointment to prepare an obituary notice of the late Dr. Jos. Carson, was received from Dr. John B. Biddle, dated Jan. 24, 1877.

Letters of acknowledgment were received from the Royal Society at Upsal (93, 94, 95; XV ii). Royal Bavarian Academy, November 19, 1876 (XII i, ii, iii; 93, 94, 95). Prof. L. Rütimeyer, Basil, November 6, 1876 (95); Literary and Philosophical Society, Liverpool, January 5, 77 (97), and the University Library at Strasburg (92—95).

Letters of envoy were received from the Royal Society, New South Wales, Sydney, July 12, 1876; Royal Statistical Society, Upsal; Royal Academy, Stockholm; Royal Bava-

rian Academy, Munich; Literary and Philosophical Society, Manchester; and Mr. Linn, Deputy Secretary of the Commonwealth, Harrisburg, returning to the safe keeping of the Library the borrowed MSS. Journal of Colonel Burd.

Donations for the Library were received from the Royal Society, New South Wales; Royal Statistical Society, Upsal; Observatory and Bureau of Statistics, at Stockholm; Royal Society of Antiq., Copenhagen; R. Pruss. A. Berlin; Ger. Geological Society, Berlin; Anthropological Society and Geological Institute, Vienna; Royal Bavarian Academy, Munich; Societies at Ulm and Giessen; Royal Belgian Academy, Brussels: Revue Politique; Astronomical Society, Victoria Institute, and Editors of Nature, London; Literary and Philosophical Society, Manchester; Philosophical and Literary Society, Leeds; Royal Cornwall Pol. Society, Falmouth; Massachusetts Historical Society; D. S. A. Green, Groton, Mass.; Silliman's Journal; Franklin Institute; Zoological Society; Pharmaceutical Association, Philadelphia; Mr. C. A. Ashburner; Librarian of Congress; U. S. Department of State; and the Wisconsin State Historical Society.

The death of Prof. Richard Somers Smith, at the U. S. Academy at Annapolis, Tuesday, January 28, 1877, aged 68, was announced by the Secretary.

The death of Mr. F. B. Meek, at Washington, December 21, 1876, aged 59, was announced by the Secretary.

Prof. Cope displayed and described some Dinosaurian remains (skull, dental bones, &c.) obtained in his last exploration of fresh water strata, in the far West, overlying the marine Cretaceous.

Prof. Cope also communicated a paper entitled "A continuation of researches among the Batrachia of the Coal Measures of Ohio."

Mr. Chase communicated a note on the "Modes of central force which best represent some of the most general forms of chemical activity."

Mr. Blodget read a copy of a bill offered for the conside-

ration of Congress, and now before the House of Representatives, authorizing the President to organize a new Arctic Expedition. Mr. Blodget called attention to the arguments in favor of such an expedition, as at present planned, set forth in a pamphlet of forty pages entitled: "Polar Colonization and Exploration, by Henry W. Howgate." As there was a great deal of postponed business for the meeting of the evening, any further discussion of the subject was, on motion of Dr. LeConte, postponed. Mr. Blodget's resolution was as follows:

Resolved, That the proposed expedition for Polar research, to be organized by the President of the United States, and to be placed under the scientific auspices of the National Academy of Science, is approved by this Society, under the assurance that it will be conducted without material risk to life. Under such conditions it may be productive of valuable results in physical science.

On motion, the reading of the list of members was postponed to the next meeting, and the list of pending nominations for membership, from No. 809 to 831, was read and the claims of each nominee in turn presented by the subscribers to the nomination.

Mr. Blodget Britton offered the following resolution, which was, on motion, seconded, debated and adopted, viz.:

Resolved, That the Officers of the Society be authorized to certify the approval of a bill to relieve charitable devises and bequests from collateral tax; and that this Society unites in the prayer for the passage of such a law.

The following is a copy of the text of the proposed law:

An act to relieve charitable devises and bequests from payment of collateral tax.

WHEREAS, When charitable devises and bequests are made for objects of public good it is unwise to diminish that good by taxation: Therefore

Section 1. Be it enacted by the Senate and House of Representatives of the Commonwealth of Pennsylvania, and it is hereby enacted by authority of the same, That all collateral taxes upon legacies and devises for charitable purposes are hereby repealed; and all such taxes not already paid into the State Treasury are hereby relinquished and released.

Mr. Briggs and Mr. Lesley opposed the passage of the

resolution on two grounds: 1. That it is not the business of this Society to advise the Government in uncalled-for cases; and 2, That the action of a collateral tax law on charities, so far from being a hardship and a reminiscence of barbarism, is on the contrary beneficial and proper for stimulating men to the right use of their wealth during their lifetime, and for protecting society in the New World against the growth of those mortmain evils which especially characterize the semi-barbarous times and governments of the past.

The contrary view was taken and supported by Mr. Blodget, Mr. Eli K. Price, and Mr. J. Sergeant Price. After which the resolution was adopted, and the officers accordingly empowered to act.

Mr. Blodget desired the Secretaries to see that a record was made of his disclaimer of any such statements and opinions respecting the character and condition of the foundations of the Masonic Temple and Public Buildings as are ascribed to him by some mistake, in the published Proceedings of the Society, No. 97, page 181. Respecting the first-named building he had not, and never had had any knowledge; and respecting the foundations of the Public Buildings he had always known and asserted their excellence.

On scrutiny of the ballot boxes by the presiding officer the following persons were delared duly elected members of this Society:

809. Prof. F. Reuleaux of Berlin, Chief Commissioner of the German Empire at the Centennial Exhibition.

810. Prof. Rudolf von Wagner of Würtzburg, Judge at the Centennial Exhibition of 1876.

811. Prof. Mariano Barcena, of Mexico.

812. Prof. E. H. Von Baumhauer, of Harlem, President of the Centennial Commission of the Netherlands.

813. Prof. George Stuart, Professor of Languages in the High School, Philadelphia.

814. Mr. W. V. McKean, of Philadelphia.

815. Rev. Charles W. Shields, D. D., Prof. of the Harmony of Science and Revealed Religion, Princeton, N. J.

816. Mr. Franklin B. Gowan, President of the Reading Railroad, Philadelphia.

817. Mr. Henry Phillips, Jr., of Philadelphia.

818. Mr. Henry Turner Eddy, C.E., Dean of the Faculty and Professor of Mathematics and Civil Engineering in the University of Cincinnati.

819. Mr. Cyrus F. Brackett, M. D., Professor Physics in Princeton College, N. J.

820. Prof. James Morgan Hart, of the University of Cincinnati.

821. Mr. Henry Armitt Brown, of Philadelphia.

822. Dr. Charles W. Siemens, of London.

823. Hon. M. Russell Thayer, Judge, Philadelphia.

824. Hon. Craig Biddle, Judge, Philadelphia.

825. T. Hewson Bache, M. D., of Philadelphia.

826. John H. McQuillen, M. D., of Philadelphia.

827. Geo. Strawbridge, M. D., of Philadelphia.

828. William Goodell, M. D., University of Pa.

829. Mr. Thos. Frederick Crane, Ph. D., Professor of Spanish and Italian in Cornell University.

And the meeting was adjourned.

Stated Meeting February 16*th*, 1877.

Present, 14 members.

Vice-President, Mr. E. K. Price, in the Chair.

Rev. Dr. Shields, Dr. Goodell, and Dr. McQuillen, newly-elected members, were introduced to the presiding officer and took their seats.

A photograph of Professor Frederick Prime, Jr., was received for insertion in the album.

Letters accepting membership were received from Mr. Henry Armitt Brown, dated Philadelphia, Feb. 6, 1877;

from Mr. Craig Biddle, dated 2033 Pine Street, Feb. 6, 1877; from Dr. Geo. Strawbridge, dated 1616 Chestnut Street, Feb. 7, 1877; from Mr. Henry Phillips, Jr., dated 304 S. Eleventh Street, Feb. 11, 1877; from Mr. M. Russell Thayer, dated Chestnut Hill, Feb. 8, 1877; from Prof. T. F. Crane, dated Cornell University, Ithaca, Feb. 8, 1877; from Dr. Charles W. Shields, dated Princeton College, Feb. 8, 1877; from Mr. George Stuart, dated 1528 N. Eighteenth Street, Feb. 12, 1877; from Dr. Thomas Goodell, dated Preston Retreat, Twentieth and Hamilton, Feb. 13, 1877; from Mr. W. V. McKean, dated [Ledger Office], Feb. 16, 1877; from Dr. J. H. McQuillen, dated 2100 Arch Street, Feb. 12, 1877.

Letters of acknowledgment were received from the University of Toronto (96, 98); and the Boston Public Library (96).

Donations for the Library were received from the Society at Lille; Revue Politique; London Nature; Essex Institute; American Chemist; Mr. A. R. Grote, Buffalo; Franklin Institute; Penn Monthly; American Journal of Pharmacy; Medical News and Library; House of Refuge; and Reading Railroad; Mr. Leo Lesquereux; War Department, U. S.; the Commissioner of Education, Washington; Mr. Sam. Scudder; Dr. Robert Peter; and the Mercantile L. Association, San Francisco, California.

The death of Dr. Anderson was announced by the Secretary, on authority of information received from Columbia College.

The death of Dr. Elisha J. Lewis, February 10th, 1877, at Philadelphia, aged years, was announced by Mr. J. S. Price.

The Secretary read a communication from Mr. Alex. E. Outerbridge, Jr., entitled "On the wonderful divisibility of metallic gold," giving a short description of an experiment made in the Assay office of the U. S. Mint, at Philadelphia.

Mr. Outerbridge electrotyped a film of gold upon a copper-plate the difference of weight before and after the process, in two trials, showing the weight of gold deposited to be 1-10 of a grain, over a surface of two

hundred square inches; which, if the gold were equally distributed in a continuous film over the whole surface, would give it a thickness of 1-980,400th part of an inch. A single grain of gold may be beaten out so as to cover seventy-five square inches with a thinness of 1-367,650th part of an inch.

The Secretary read a communication entitled "A measured section of the Palæozoic Rocks of Central Pennsylvania from the top of the Alleghany River Coal Series (on Broad Top) down to the Trenton Limestone, in the Lower or Cambro-Silurian System." by Charles A. Ashburner, Assistant on the Second Geological Survey of Pennsylvania.

Gen. Kane resumed the reading of his communication made at a recent meeting of the Society, describing his personal observations in Mexico, and discussing the ethnological movements taking place in that part of the American Continent.

Professor Cope exhibited and described some fossil remains of a Dinosaur, found by Dr. Newberry in 1870, in one of the cañons of the mountains of Utah, the first ever discovered in Triassic rocks in that part of the Continent. He compared them with others found by himself in 1874.

Professor Cope exhibited drawings of scratched figures on coal shales said to have been formed in an Indian mound near Davenport, Iowa, and now preserved in the Museum of the Davenport Academy of Sciences. One of these drawings represents a kind of zodiac, and the other numerous forms of animals, some of which are easily recognized, while those of others are unknown. These drawings are of such unusual excellence of design, and the accompanying symbols and letters have so Indogermanic an aspect, that doubts were expressed by some of the members present concerning their genuineness.

Pending nominations 830 and 831, and new nominations 832, 833 and 834 were read.

The resolution of the Finance Committee postponed at the last meeting was taken up, and on motion an appropriation

of $1500 (fifteen hundred dollars) was made for continuing the printing of the Catalogue of the Library.

Gen. Kane read the following joint resolution offered to Congress.

Resolved, That the President be authorized to confer with the authorities of Mexico for the establishment of a joint commission having for its object the scientific exploration of the border States of Mexico and the United States; the operations of the commission to be conducted under the advice of the National Academy of Sciences. *Provided however*, that nothing herein contained shall be construed as to involve the United States for the payment of any claim which may grow out of such action or proceeding. Act, July 12, 1870.

On motion of Gen. Kane, it was resolved that this Society approves of the passage by Congress of the above Resolution; heartily commending the scientific exploration proposed, and the form of organization suggested.

And the meeting was adjourned.

Stated Meeting, March 2nd, 1877.

Present, 15 members.

Vice-President, Mr. Price, in the Chair.

Dr. Bache, a newly elected member, was presented to the presiding officer, and took his seat.

Letters accepting membership were received from Prof. C. F. Brackett, dated Princeton, Feb. 17, 1877; and Prof. Henry Turner Eddy, C. E., dated University of Cincinnati, Feb. 26, 1877.

A photograph for the album was received from Dr. Geo. W. Anderson, of the American Baptist Publication Society, 1420 Chestnut Street, Philadelphia.

A letter requesting a set of Proceedings for working pur-

poses was received from Prof. J. J. Stevenson, dated 314 West 30th Street, N. Y., Feb. 15, 1877; and on motion the request was granted.

A letter requesting No. 73, 75 and 80 of the Proceedings of the Society, and the loan of any cuts relating to the subject of Indian sculptures in the possession of the Society, to be used by him in his work on Indian Antiquities, was received from Mr. E. A. Barber, West Chester, Pa., with references to Prof. T. C. Porter, of Easton. On motion the Librarian was directed to correspond with Prof. Porter, and authorized to grant Mr. Barber's request.

Letters of acknowledgment were received from the Radcliffe Observatory, Feb. 12, 1877; and the Franklin Institute.

A letter of envoy was received from C. P. Ob., St. Petersburg.

Donations for the Library were received from J. J. A. Worsaac, of Copenhagen; Annales des Mines; Revue Politique; Geographical Society and Bureau des Longitudes, Paris; Royal Astronomical Society; Victoria Institute and London Nature; Nova Scotia Institute at Halifax; the Editor of the Naturalist's Directory, Salem; the A. Antiq. Society, Worcester; American Chemist; Index; Mr. Potts of Camden, N. J.; Mr. Fred. Graff, Mr. Hermann Haupt, and the Mercantile Library Co., of Philadelphia; Commissioners of Second Geological Survey of Pennsylvania; U. S. Corps of Engineers, and Public Library of Indianapolis.

The death of Rear Admiral Davis at Washington, Feb. 25, 1877, aged years, was announced by the Secretary.

Professor Sadtler communicated the results of his recent gas analyses; and Mr. Lesley described the importance of the investigation in a geological sense, as the first ever published which took into account the elements of depth hypsometrical, depth geological, order and age of the oil horizons, and geographical distribution of the groups of wells in a north and south direction from Pittsburgh to Buffalo.

Professor Cope exhibited a vertebral column, thirty-three feet long, of an unusually perfect Elasmosaurus, to which he

gave the specific name of *Serpentinus*, and described the points in which it differed from *E. platyurus* (Cope), a description of which had been given at a meeting of the Society nine years ago, and was published in its Transactions.

Professor Cope also communicated evidence of the existence of a new species of Mastodon in the United States, and proposed for it the specific name *M. trementinus*.

Mr. Chase called attention to some experimental results, illustrating his 6th, 7th and 10th fundamental propositions of central force.

Professor Blazius read a paper entitled "The progress in Meteorology, and its tendency during the last twenty-five years; with some supplementary notes to a recent English work bearing that title.

Pending nominations 830, 831, 832, 833 and 834 were read.

And the meeting was adjourned.

Stated Meeting, March 16th, 1877.

Present, 12 members.

Vice-President, Mr. PRICE, in the Chair.

Mr. McKean a newly elected member was introduced to the presiding officer and took his seat.

Letters accepting membership were received from Prof. J. M. Hart, dated 228 S. Broad Street, Philadelphia, March 2d, 1877; and from Prof. F. Reuleaux, dated Berlin, Feb. 20, 1877.

Letters of acknowledgment were received from E. A. Barber, dated West Chester, Pa., March 12, 1877, (73, 75, 80); the Lenox Library, dated New York, March 14, 1877, (96, 98); and Prof. J. J. Stevenson, dated 314 W. Thirtieth Street, New York, March 7, 1877 (65 to 98).

A letter of envoy was received from Prof. Daniel Kirk-

wood, dated Bloomington, Indiana, March 8th, 1877, with a MSS. communication.

Donations for the Library were received from the Royal Society, New South Wales; the Editors of the Flora Batava; the Royal Belgian Academy; the Revue Politique; the M. C. L., Cambridge, Mass.; Silliman's Journal; New Jersey Historical Society; Astor Library; Mr. E. A. Barber, Prof. P. Frazer, Jr., Dr. Hewson Bache; the Medical News; Journal of Pharmacy; Franklin Institute and Penn Monthly; War Department at Washington, and Don J. Ramon de Ybarrola, of Mexico.

A communication was read by the Secretary entitled, "On Eight Meteoric Fireballs, &c., by Daniel Kirkwood, Professor of Mathematics, Indiana University, Bloomington, Indiana."

Prof. Blazius continued the reading of his paper on "The tendency of modern meteorology."

Dr. Wood communicated a paper entitled "On the asserted antagonism of Nicotia and Strychnia, by Francis L. Haynes."

The Secretary communicated a paper entitled, "Notes on the results of a survey of the iron ore beds of the Juniata District of the Second Geological Survey of Pennsylvania by John H. Dewees."

Prof. Cope exhibited and described a cast of the brain cavity of *Coryphodon elephantopus*, of which a complete skeleton exists, and discussed the homologies of the organ, and showed that the genus to which the animal belongs properly constitutes a fourth sub-order of mammalia lower in type than the Marsupialia.

Pending nominations Nos. 830, 831, 832, 833, and 834 were read.

Prof. Chase offered the following preamble and resolutions, which were seconded, discussed and adopted:

Whereas, It is of the greatest importance that the investigation of natural phenomena, such as the origin and migrations of creatures, noxious

to agriculture, should be directed by disciplined men of science, of acknowledged ability and trustworthiness, and

Whereas, This Society has been informed that a vacancy may occur in the post of Commissioner of Agriculture in the Department of the Interior, and

Whereas, The name of our fellow member, and distinguished naturalist and entomologist, Dr. John L. LeConte, has been put forward for recommendation to the President for said appointment, therefore

Resolved, That this Society heartily endorse such recommendation.

Prof. Frazer offered the following resolution:

Resolved, That this Society recommend to its members in the presentation of papers containing references to length, weight and capacity, to add to such units as they may deem preferable, the metric units.

Dr. Rogers offered the following amendment:

And also, That those who may use the metrical system shall convert the same into the English.

The resolution and amendment were ordered to be published on the card of notice for the next meeting, and discussion on their merits was postponed.

The meeting was then adjourned.

(*Continued on page* 661.)

On the Progress of the North American Carboniferous Flora, in preparation for the Second Geological Survey of Pennsylvania.

By L. Lesquereux.

(*Read before the American Philosophical Society, January* 5, 1877.)

The purpose of this memoir is to give a short account of the progress which has been made, to this day, in the preparation of the North American Coal Flora as one volume of the current Reports of the Second Geological Survey of Pennsylvania.

At first it seemed appropriate to prepare for publication, and in order to preserve the right of priority of names, a catalogue of the species which have to be described in the Flora, and to define the essential points of the classification, especially the generic divisions.

Details of classification, however, cannot be positively fixed before all the materials used in the preparation of the descriptions of the species have been definitely examined. Then the manuscript of the flora will be ready for the printer and a synopsis of it would be useless. Moreover, a mere enumeration of names would offer little of general interest.

It is therefore more advisable to give in advance an *exposé* of the plan which has been followed in the researches deemed necessary for the preparation of the work; of the available sources of information; of the materials, when and where collected for it; of the point arrived at until now, and, therefore, of the more interesting data which have to be exposed in the publication of this Flora.

Those who have ever examined what is generally called specimens of coal plants, know that they generally represent parts of trunks, whose surface is marked by peculiar impressions; or branches without leaves, whose relation is recognized also by the scars upon their bark; or, for the ferns, especially, fragments or pinnæ of fronds with leaflets, or more generally, of detached pinnules, which, though they may be beautiful, do not give, when considered separately, an idea of the general or true character of the vegetable to which they belong. The classification of the living species of the great family of the ferns is derived more especially from the characters of their fructifications. In the coal, though the ferns constitute by far the greatest part of the vegetation, their fructifications are rarely found, and when found, they are mostly attached to branches or pinnæ separated from the sterile fronds, which then, were, as they are now, often very different in aspect and characters from the fruiting ones. Hence it is very difficult to ascertain their correlation; and thus the paleobotanist may place in one genus a sterile branch when he has to describe the fertile pinna of the same fern, in another. Long ribbon leaves, hard fruits of various shape, also are frequently seen in the shale of the coal; but these are most rarely, if ever found attached

to stems, and, therefore the relation of many of them to the plants which they represent prevents their reference to original types, and forces, for their description, an artificial classification which the discovery of a single specimen may overthrow. Hence it happens that, in the pursuit of his researches to recognize the specific characters or even the more distant relations of the vegetable fragments, the paleontologist is forced to look for and to compare a large number of specimens before he is able to fix their references. The subdivisions of the leaves or fronds of ferns, the pinnæ and pinnules, have not between the same species that kind of likeness or affinity of shape remarked between the leaves of dicotyledonous plants. The modifications of form are not only extremely numerous, but present such an anomalous diversity, that botanists unacquainted with this section of natural history could often suppose no generic relation between some of the leaflets which represent the same species. One of the most common ferns of the middle coal measures, a *Neuropteris*, for instance, is nearly always found in detached, fine, large, cordate-lanceolate leaflets, which sometimes measure four to five inches in length and two or three inches in diameter. Some small round or broadly oval pinnules are generally found mixed with those large leaves; they are not even half an inch in diameter; and though they have a similar character of nervation, the difference in shape and size is so marked that they were of course described under a different specific name. Lindley and Hutton were the first to suppose, from their coincidence of local distribution, that they might possibly represent parts of the same plant. Since then, and long afterwards, large branches of fronds have been discovered in this country with the two forms of leaves attached to the same pedicel, the large leaves being borne upon a short stalk, with two small leaflets attached to their base. A number of cases of the same kind might be mentioned; but this one is sufficient, and I quote it not merely to show how great are the difficulties encountered by the botanist in the study of coal plants and what persistence it demands, but to prove that the discoveries made in the coal flora of this continent render now to European paleontologists the same amount of assistance that we have received from their works in former times.

The remains of coal plants, generally pleasant to the eye by their graceful shape, and some of them of very peculiar forms, widely apart from those which are generally observable in the vegetation of our time, could not but, as wonderful productions of nature, excite the interest of the first investigators of the carboniferous measures of Pennsylvania. Already in 1818, Steinhauer had published in the Transactions of the American Philosophical Society his *Fossil reliquia*, where remains of plants now referable to *Calamites*, *Lepidodendron*, *Ulodendron*, *Artisia*, *Sigillaria*, and *Stigmaria*, are figured and described under the collective name of *Phytolithes*. He does not represent any kind of fern; but he mentions in the introduction that most of the specimens of fossil plants from the carboniferous are *Filices* (ferns). After him, in 1820, Granger mentions without descriptions a few specimens of coal plants from Zanesville, Ohio. From that time

to 1828, Granger, Cist and Professor Silliman sent a number of specimens to Brongniart, who was then engaged in the publication of his great work upon the flora of the coal. In 1831, Professor Eaton described with figures a fossil scale tree, (*Lepidodendron*), sent to him from Montrose, in Bradford County, Pennsylvania.* In 1833, the same author remarks that Professor James Hall had made in Pennsylvania the most extensive collection of vegetable fossils that had hitherto been made on this continent, and gives the names of six species which had been determined by the aid of Brongniart's figures and descriptions, adding that he had before him twenty-five ascertained species from the coal measures of Pennsylvania. Already in 1831 the description of *Fucoides Brongniarti* was published by Harlan, who had discovered it and mentioned it before as *F. Alleghaniensis*. This species was later redescribed by Hall in Pal. of New York, as *F. Harlani*, and later still Göppert, in his Flora of the Transition measures, rendered a just tribute of homage both to Harlan and to Hall in describing it anew as *Harlania Hallii*. I find in the same historical record of Professor Lesley, mention of a splendid collection of coal plants made at great expense and presented to the Geological Society of Pennsylvania by Dr. Martin. This collection, it seems, has been lost. Then, of a plate of fossil plants of the New Red of Virginia, by Mr. F. G. Clemson; farther on, a paper by Harlan on coal plants, four species of which are figured; and later still, some remarks from the same naturalist upon a species of *Equisetum* referrable to *Asterophyllites* or *Annularia*. To this I may add the record of a memoir published in 1837 by Dr. Hildreth, in Silliman's Journal, where this able geologist and noble man has figured a number of coal plants, mostly undescribed and without names, some of them of indefinite relationships; and of another memoir published in 1847 by Dr. Teschmacher of Boston, who mentions twenty-three species of coal plants from Massachusetts and Rhode Island, some of them figured, and more or less distinctly referrable to species known from the works of European authors. For, at that time, the coal flora of Europe had been already studied with great activity, and besides the works of the older authors, Schlottheim, Artis, Lindley and Hutton, Sternberg, which have lost nothing of their scientific value even to our time, the paleobotanists of America had for points of comparison of their fossil plants the Flora of Brongniart, and his numerous memoirs on coal plants published from 1821 to 1844; a pamphlet of Berger on the fruits of the coal; Corda's Beiträge, a splendid work on the internal structure of fossil trunks and stems; Germar's work on the fossils of the carboniferous of Wettin; Göppert's Systema, 1836; and later, his genera (Gattungen), published from 1841–48; Gutbier; Unger on the *Calamites*; and less important memoirs of authors, Binney, Geinitz, Schimper, Roemer, etc., who have now become far-famed by notable works on the vegetable paleontology of the coal.

From this rapid synopsis it may be seen how little was known of the carboniferous flora of North America when, in 1851, I was called to join the

*I quote this and the following data from Professor J. P. Lesley's historical sketches, as I have had no access to the mentioned memoirs.

corps of the first Geological Survey of Pennsylvania as Paleobotanist, and was then requested, not merely to collect and study the coal plants, and to give an account of them, but to find in regard to their stratigraphical distribution some data which might be of application for the determination of the relative position of the coal beds. I went to work then; but when I look now upon those first researches of mine, I can but feel a deep sense of commiseration for that student of American paleobotany who had never before seen an American specimen of fossil plants, and who was called to prepare a full record of a flora which after twenty-five years of incessant work is as yet, and will ever be, incomplete; and to decide upon problems as far from solution now, after the multiplied researches of a score of naturalists of the highest standing, as they were thirty years ago. And this commiseration does not apply merely to the results of the work, but to the labor itself. I had as yet never had any collection of coal plants of my own, and thus had no points of comparison whatever. I had merely studied these plants in some of the more important cabinets of Europe, especially that of Strasbourg, which had furnished to Brongniart a large part of the materials used for his Flora. And, except a copy of Sternberg lent to me by the director of the survey, I had no books. The work had to be done, however. Spending days, even whole weeks, upon the great heaps of black shale, now such a marked feature of the landscape of the Anthracite fields; cutting and turning over those shales, sometimes heated by the sun to such a degree that they could hardly be taken into the hands; comparing incomplete fragments in trying to recognize the original characters of the plants; carefully collecting all that seemed of any value to my purpose, and heaping and transporting lots of specimens on my back, however great the distances might be, I had soon materials enough at my command. For then most of the mines were new openings; the shales were generally taken out, and lay uncovered, and some of the coal beds were very rich in fossil remains. Moreover, I found already some fine cabinets of fossil plants open to me for examination; that of Mr. Clarkson of Wilkesbarre; of Mr. Jones of Carbondale, both very intelligent gentlemen, superintendents of coal mines; and many fine specimens, isolated as curiosities by hotel keepers or land proprietors, were presented to the survey. All these specimens after being examined and labeled by a No. of order corresponding with those of my book of references, in which remarks on the specification were written, were boxed and sent to the address of Professor Rogers at Philadelphia; except, however, those which had to be figured for the plates of the report, or which as yet, of uncertain relation, had to be more carefully studied.

At the suggestion of the director of the survey I had prepared for publication in the Boston Journal of Natural History (August, 1854) an abridged description of the new species of fossil plants found in the coal fields of Pennsylvania. But the final report was mostly made at the house of Prof. Rogers at Boston, where all the specimens of the survey were then, and where I spent three months in a final review to close the memoir

on the fossil flora of the coal. When I delivered it, it was with the understanding that I should have the privilege of reviewing the manuscript before it was delivered to the printer, or at least of correcting the galley-proofs. But I heard nothing more about it, nor a word from Prof. Rogers; and thus I supposed that the publication of the report had been abandoned; when I received, in 1858, a printed copy of the plates, with a note requesting me to correct them if I found it advisable, and stating that the report was already definitely printed. Of course, as I had no copy of the manuscript, nor any proof prints, I could not correct the plates, which are moreover satisfactorily engraved. It is not necessary to say that if I could have reviewed the memoir before its publication it would have been, if not re-written entirely, at least greatly modified; for after some years of further researches for specimens of coal plants in the Pennsylvania anthracite fields, I should have had some important corrections to make and a number of interesting data as additions to it. For indeed its phraseology is very poor, the descriptions incomplete, and some of the species incorrectly named; the orthography of the Latin names especially is abominable; but as it is the same for the nomenclature of Prof. Rogers, the printer is accountable for the defect. Even on the subject of incorrect determinations of species little has been criticised of the memoir by European authors, and the continued examination of a great number of specimens up to this time has confirmed them with few exceptions. *Asterophyllites ovalis* and *crassicaulis* are fruiting branches now referred by some botanists to *Annularia*, by others to *Sphenophyllum*, by myself still to *Asterophyllites*. The characters of these remains are now known by specimens as complete as may be obtained of petrified vegetable organisms; their relation is, however, not determined upon, and is still in discussion among European authors. *Alethopteris obscura*, of which a mere fragment, seemingly far too incomplete for satisfactory determination, is represented Pl. I, was later discovered at the same locality, in whole pinnæ, which show the same characters and relation as marked in the first description. *Cyclopteris* (*Neuropteris*) *fimbriata* has not only been found at different places, especially in Illinois, always representing the characters originally ascribed to it, but even Prof. Heer, who, when the species was first published, considered it as an imaginary or abnormal representation of leaves of ferns, has it now from the anthracite measures of Switzerland, and has described two species remarkably similar to or perhaps identical with it. The splendid *Neuropteris Rogersii* has been found again in many specimens, at the same and only locality where it had been originally discovered, preserving its identity of characters. Another specimen also has been obtained of the queerly branching *Sphenopteris Newberryi*, with the same peculiar forking of its pinnæ. And the *Lepidodendron* species, though multiplied too far according to Schimper, have been studied from an immense number of specimens from the lower plant bearing strata of the whole extent of the North American coal measures, and their specific characters have been found persistent upon large trunks and upon small branches, therefore with

the scars of very different size. Some corrections have to be made, as said above, but certainly not more than would be demanded for a work of this kind, pursued under the most unfavorable circumstances, twenty years after its publication.

After the close of the survey or of the exploration under the direction of Prof H. D. Rogers, I had continued, on my own account and at my own expense, the explorations for the study of the coal plants of the anthracite fields of Pennsylvania. In the fall of 1857, while stopping at Pottsville for the examination and determination of a large lot of specimens of fossil plants in the cabinet of the Pottsville Scientific Association, I was requested by some members of the society to prepare a catalogue of all the species which had come under my examination in Pennsylvania and other States, including the species which I had then recognized in the Pottsville cabinet. This catalogue, delivered February 1858, was immediately published. It comprises the names of 286 species, including those copied from a list of the species of coal plants from Ohio by Dr. Newberry. Most of the species described in my report to Prof. Rogers are named, and form the largest part of it; some however being left out as uncertain, others added and described and figured as new. No reference is made in this catalogue to the Pennsylvania Geological Report for the good reason that I did not know if this report should ever appear in print. But as the new species described in it had been already published, and their names were thus public property, and as the others were those of species described by European authors, I was then and am now still unable to see how the publication of this catalogue could be considered as a breach of literary obligation, according to the expressions of the Pennsylvania report, p. 878. It is certainly needless to say any more on the subject.

I had at that time become acquainted with the fossil flora of the Pennsylvania coal measures quite as sufficiently as I thought needful for my purpose, and I was anxious to pursue the exploration in other coal fields in order to be able to study the characters of the vegetation of the coal at distant localities, for the elucidation of more important questions, those especially referable to the geographical and stratigraphical distribution of the species at the carboniferous period. For it would not do to attempt to expose a history of the American coal flora merely from data obtained in Pennsylvania. With this idea I began a new series of field explorations, and the examination of all the collections of fossil plants to which I could gain access; and this work has been pursued nearly uninterruptedly until now. First I went, twice, along the Ohio river from Pomeroy down to Gallipolis, and up the Kenawha river to the salines of Charlestown, Virginia. I had then the opportunity to see the cabinet of Dr. Hildreth at Marietta, and to begin with this justly venerated geologist a series of relations and mutual communications continued to his death. At Charlestown I had access to a fine cabinet of specimens of the Rev. Mr. Brown, who had a number of interesting and new species. I collected myself good material for study in the mines worked then above that place. I visited the more interesting

portions of the coal measures of Ohio ; twice the mines of Cuyahoga Falls ; those along the railroad from Cleveland to the mouth of Yellow creek ; the coal strata under the Flint ridge near Newark ; those of Zanesville and down the Muskingum river, thus passing over the coal fields in various directions.

I had been before to Nashville to see Professor Troost and his celebrated cabinet of mineral specimens, which had then scarcely anything referable to vegetable paleontology. I found later, however, at Lebanon, in the collections of Prof. Jas. M. Safford, State Geologist of Tennessee, a fine lot of remarkably well preserved impressions of ferns, with some hard fruits, *Carpolithes, Trigonocarpes,* some of them new species.

These private researches becoming too expensive for my very limited means, and also too little productive in results of importance to my researches, I readily accepted the proposition of Dr. D. D. Owen, to join his corps of assistants on the Geological State Survey of Kentucky, and gave to the work two or three months each year. These explorations were of little account, and did not afford any valuable discoveries in vegetable paleontology. For except the coal beds of the upper stage, worked for the use of steamboats along the Ohio river, and which had no fossil remains of plants, most of those exposed inland were then unopened for want of communications, and thus I had rarely any opportunity to get good specimens.

The results of the geological *reconnaisance* in Arkansas, under the same direction, were far more valuable and interesting. But here, again, it was impossible to stop at peculiar places for prolonged investigation for fossils. So hurried were the explorations made, with the necessary incumbrance of a camp, that for the examination of the finest exposition of a coal, that of Malés, where there was an abundance of specimens, we had scarcely one hour of time. This exposure was at the top of a mountain where no water and no feed could be got for the horses, and arriving at the mines late in the evening when it was already nearly dark, we had to leave at daybreak, and thus was lost the only good opportunity I had to compare the characters of the sub-carboniferous flora of that State with those of the true carboniferous of the Eastern basins.

The specimens hastily secured in that short time, however, proved very valuable ; for if they did not represent a number of species sufficient for a determination of the general character of the vegetation, they showed mostly new types, as may be seen in the second volume of the Arkansas Geological Report, where they have been described and figured in five plates.

My next explorations in connection with the Geological State Survey of Illinois were, per contra, very productive in valuable discoveries in relation to the flora of the coal. The very able chief of the survey, A. H. Worthen, then gave not only to the direction of the work the greatest energy, looking for every possible opportunity of examining himself the coal strata whose station was still uncertain ; but whenever we had chances of obtaining fossil remains he gave me sufficient time and his own assistance for

collections which, transferred to the large State cabinet of Springfield, were afterwards examined and determined at leisure. Some localities, like that of Morris, Grundy county, for example, where the vegetable fragments are preserved both in soft shale, and in very hard concretions, afforded a rare opportunity for the study of a local distribution of the coal flora and also of a remarkable exposition of its richness and luxuriance. For the concretions there hold in preservation some of the small and soft vegetable remains which are generally destroyed by a protracted maceration in porous materials like shale or sandstone. There were moreover at Morris some private cabinets of gentlemen interested in fossil botany by the beauty of the specimens obtainable in the vicinity, those of Jos. Even, S. S. Strong, Prendel, Armstrong. These were kindly opened for my examination, and afforded abundant materials for study. The essential results of the paleobotanical explorations in Illinois are exposed in the second and fourth volumes of the Geological Reports of that State, and their importance may be judged by the table of species, Vol. IV, p. 471, whose number amounts to two hundred and twenty-six, a number which has been greatly increased since then. Some of the species recognized in the flora of Morris are extremely interesting, remarkable indeed for characters which had nowhere been recognized until then in the vegetation of coal, and which therefore might be supposed to be somewhat imaginary or derived from obscure specimens. These, however, like *Neuropteris Verbenæfolia*, *N. pachyderma* of the second volume, have been re-discovered in better specimens, though the first were already satisfactorily determined. And this was the more opportune that the first and only specimens used for exemplification and belonging to Mr. Even had been lost by a fire which destroyed his whole property. This second volume also figures some peculiar species to which is attached a double importance and significance, by their own characters, and by their relations to types generally considered as strangers to the carboniferous formations. Of these I will say something more after finishing the enumeration of the means employed for increasing the amount of materials serviceable for the study of the coal flora.

While occupied with the surveys, I had always, in pursuance of the same plan, looked for every opportunity of examining local collections or encouraging local researches for specimens of fossil plants. The specimens of Amherst College had been entrusted to me for determination. I had seen also those of Yale College, those of Prof. J. D. Dana; determined the species in the cabinet of Princeton College, and established correspondence for exchanges or communications; among others with Mr. T. H. Clark, of Newport, R. I., who had for a long time collected specimens of plants from the coal of Mount Hope, which by and by gave a very interesting contribution to the North American coal flora. More recently a new light was thrown into the obscure question of the vertical distribution of the coal flora and upon the characters of its groups, by the communication of a whole cabinet of fossil plants from the coal fields of Alabama, sent for determination by the Director of that Geological Survey, Prof. Eug. A. Smith.

A mere catalogue of the names has been published in the first volume of his first report, together with a reference to the group or geological division indicated by these plants. The remarks then made on this subject have been confirmed by subsequent communications of specimens from the same coal fields; those of Mr. T. H. Aldrich, proprietor of the Montevallo coal, and of Mr. Thos. Sharp, Superintendent of the Newcastle Company.

Since my connection with the Second Geological Survey of Pennsylvania explorations of the same kind have been pursued with renewed activity, and these have been still more fruittul and more interesting than those of old. They have greatly increased and multiplied the field of researches, constantly adding new materials to those which were at hand, and thus showing how great is the richness of the vegetation of the coal, and how backwards we are yet in our acquaintance with it. We have now a group of fossil plants from Clinton, Mo which, collected by Dr. Britts in lower carboniferous very productive shale, not only represents many new species, but, taken in the whole, affords a fair point of comparison for the western lower coal measures. Another from the Cannelton Coal of Beaver county, Pa. (Coal C, of Lesley), where M. J. F. Mansfield, the proprietor, has, at great expense of time and money, pursued systematic explorations in the roof shales, which there hold remains of plants in profusion. This local flora will become an important representative of the vegetation of the middle part of the lower carboniferous. Prof. Worthen has sent a lot of plants, some of them of new and remarkable types, from under the Chester Limestone of Western Illinois; and Prof. E. T. Con, another not less interesting from the Whetstone grit of Indiana, which overlies the same sub-carboniferous formation. From the same geologist I have had for determination a number of specimens of fucoids, or remains of marine plants, very remarkable in their typical relations, all discovered in the coal measures of Indiana. Though these do not belong to the Pennsylvania survey, and have been described in the last report of Indiana, they pertain, of course, to the Coal Flora. And more still, we have received from Illinois a lot of specimens from the pseudo-carboniferous, representing plants of the same characters as those discovered by Prof. E. B. Andrews in the Waverly Sandstone of Ohio. This communication is due to Mr. S. H. Southwell, of Fort Byron, Ill. who discovered also at about the same horizon specimens of one of the species of fucoids described in the Indiana report.

Last fall I visited twice the sub-carboniferous coal beds around Sharon and Youngstown, to ascertain the character of their vegetation, and obtained valuable specimens, some of them of new species. I made also a short tour of exploration in the basins of the Swatara river and Raush creek to compare once more the plants of the Mammoth with those of the Salem vein. Besides the specimens found by myself, a number of others were then presented to the Survey by Mr. T. Price Wetherill, of Tremont. Mr. W. Lorenz, Superintendent of the Philadelphia & Reading

R. R. directed the researches to the more interesting localities, presented to me all the specimens found by himself, and when I returned to Philadelphia gave me the privilege of examining his cabinet, to select from it all the materials which might be of use to my work.

The last, but not the least, important communication to the Survey is due to Mr. S. S. Strong, of Morris, Ill. I have already remarked upon his cabinet, which was opened for my researches in connection with the Geological Survey of Illinois. Since that time this proficient explorer of vegetable remains has constantly increased his splendid collection, especially from the nodules of Mazon creek. Lately he proposed that I should go to Morris to make a fair review of his specimens and to determine them, offering to the Survey, as a compensation to my work, all those which I should consider as representatives of very rare or new species. This examination has added an important store of materials of great value to those which we had already; and it is evident that by the addition of a number of species of various types, either new or not observed before at Morris, we have in the flora of that locality the best possible point of comparison for geological distribution of the coal flora; while, by its station between the two essential subdivisions of the coal measures, it offers the same advantages for judging of the modifications of the plants in passing from the sub-carboniferous upwards.

To close this enumeration of the resources now in store for the preparation of the North America Coal Flora I have still to mention the publications made in this country upon the same subject; for of course this Flora has to take into consideration the materials used in the preparation of these works. The most important ones are the memoirs of Professor J. W. Dawson, of Montreal, who has studied for years the Devonian and lower carboniferous floras of Canada, and of the Western States with a patience and industry which have justly rendered his name famous. After this in degree of importance we have, in the first volume on the Paleontology of the Geological Reports of Ohio, a valuable monography of fruits of the carboniferous by Dr. Newberry. It throws much light upon the true characters of those vegetable remains so rarely found in a good state of preservation, and so difficult to study, especially in regard to their relationships. A number of them had been briefly described, by the same author, in the Annals of Science, 1853. The second volume of the same Report is enriched by a memoir of Professsr E B. Andrews, upon species of fossil plants discovered by himself in the formation of the Waverly Sandstone of Ohio. By the precise descriptions and the splendid illustrations of the species representing new typical forms of the vegetation of the coal this memoir is indeed an important contribution to vegetable paleontology. We had had before upon some species of the *Vespertine* of Virginia a too short paper from Professor B. F. Meek, with two fine plates of illustrations, and an accuracy of description which so remarkably characterized this paleontologist who leaves behind him a wide-world repute. This has been followed up by another memoir on the conglomerate series of Virginia, by Pro-

fessor V. Fontaine. No plates are given as illustration of the species; but these are so carefully described that the characters are easily recognized without figures. In connection with Professor I. C. White, these gentlemen are now studying a lot of fossil plants whose discovery is due to Professor John J. Stevenson, but whose specimens were collected by themselves. They represent an upper section of the carboniferous, apparently touching on the Permian. The results of this study which they intend to publish soon, can not fail to add new materials which ought to contribute to the fullness of the coal flora.

From all that has been seen above it is clear that this *Coal Flora*, in preparation for the second Geological Survey of Pennsylvania, is not merely a description with figures of the species of the coal measures of that State. The concentration of such researches within precise geographical limits would deprive them of any importance, and of any scientific value; for the work done in that way would give only a very meagre representation of the vegetation of the coal period, and it is desirable to know it in its whole extent, as far as our acquaintance with it has advanced until now. I purpose, therefore, to consider all the plants found in the coal measures, from the eastern limits of the continent (New Scotia, New Brunswick) to the eastern borders of the coal fields in Kansas. Even farther West, in the Rocky Mountains, a few remains of *Calamites* have been found. They represent merely two species recognized in the Permian as well as in the carboniferous of Europe, and they offer no great interest by their specific characters. They have to be described, however, as serviceable for comparison in case of future discoveries. And considering the vertical distribution of the vegetation of the coal, it is advisable also to give to this flora the widest possible range, and to admit into it all the species of land plants recognized on this continent, from the first appearance of land vegetation in the upper silurian strata, to the end of the carboniferous period. The true devonian species, those which have not yet been observed in the Catskill or Old Red sandstone, now considered as lower carboniferous, are very few in number, not more than half a dozen perhaps. It is probable that similar or related types may be recognized hereafter in the true coal measures. We want to know them, therefore, for eventual comparison. Moreover, they enter into the history of the coal flora as ancestors; and in its records nothing should be omitted which may throw any light into the important question of the development of the primitive types, reappearing under modified characters. I quote a single example as illustration. There is in the coal of Morris a species of *Neuropteris*, with leaflets seemingly branching in an anomalous way, by the splitting of the rachis either at the base or in the middle of the leaflets. This species, described as *Neuropteris fasciculata*, has been considered as a kind of monstrosity or a casual decomposition of the leaflets, as we see sometimes in the living flora. But the same character is seen already in *Megalopteris*, a species of the lowest coal measures; thus we find it continued in that *Neuropteris* of Morris, and thereby have a proof of its persistence from the base to the middle of the carboniferous.

Let me now answer the questions which the above exposition may have suggested. What is the purpose of this work? What are the results already obtained from the researches? What may be expected of its completion? A constantly more intimate acquaintance with the characters of the coal flora is the first and natural result of prolonged and extensive explorations. This will not say, however, that we shall have by this a full history of the vegetation of the coal. For, as it has been remarked in the beginning of this paper, the fossil vegetable remains of the coal are generally mere fragments, which, considered separately, do not show the characters of the whole plants to which they pertain These can be recognized only by the comparison, sometimes of a large number of specimens; and it may even be said that many of the species of the coal are without any scientific value, for the reason that they are defined by characters which belong to mere fragments. And the deficiency of reliable specific characters apply not only to the coal plants themselves, but become more evident still in the attempts made to fix their relation to the plants of our time.

The insufficiency of the evidence afforded to the student by those mere fragments of vegetables has been complained of by the most sagacious paleontologists, and has discouraged the most ardent followers of Paleobotany. Lindley and Hutton bitterly lament it in their fossil flora of Great Britain, which, however incomplete it may be, has become a classic or leading work, and is now re-edited in its integrity. Hooker, the prince of the botanists of our age, while connected with the Geological Survey of England, makes, in his report, a comparison of the vegetation of the coal with that of our time, and devotes the largest part of it to exemplify by figures and descriptions how rarely fragments of ferns may represent the characters of the species to which they belong. He has, however, in the exposition of the structure of the *Stigmaria* and of *Lepidostrobi*, the fruits of *Lepidodendron*, anatomically studied from silicified specimens, thrown such light on the affinity of those plants, that his too short memoir is considered as the most important on the subject. Brongniart, also a prince among the botanists of his time, spent many years in exploring the coal measures of France and Belgium, in visiting all the museums where specimens of fossil vegetables were preserved, before he began, in 1828, the preparation of his great work on the fossil flora of the coal. Adding to his stock of materials by exchanges and by communications received from the scientific world at large, he pursued his labors until 1844, when he abandoned the work half done. His *Flora* is, however, even now the most reliable guide to the student of Paleobotany. Göppert, too, supposing that from the immense number of specimens of coal plants gathered into his splendid cabinet he should be able to fix a new classification of the ferns of the coal from the characters of their fructifications, began his Genera (*Gattungen*) in 1841, and abandoned it, discouraged, after six fascicules had been published. This work, however, incomplete as it is, has, by the exemplification of the structure of a number of forms of the fructifications

of ferns, directed researches toward this new field of exploration and opened a path which, by and by, enlarged by new discoveries, may afford a more reliable way for the determination of species of this family. Still more recently, Goldenberg attempted a detailed monography of the fossil plants of Saarbruck (*Flora Saræpontana*), where he had found an abundance of valuable materials. Of it he published only three fascicules; but they represent a valuable monography of the *Sigillariæ*, and this also is a gain to the fossil flora.

What conclusions may be derived from this? Shall we say that the coal flora cannot be studied with advantage from a number of specimens observed at peculiar localities? Shall we admit that this flora cannot be studied at all, and that it should be left in its grand and sublime mystery? The first assertion is right; the second rests upon an objection, which may be made against every study, which tends to the interpretation of documents whose writing is as yet imperfectly known. The hieroglyphs of the Pyramids are still more obscure, still farther from exposing a comprehensive record of the history of the people who built them. Some have been deciphered, nevertheless, and a few pages of the writing have thrown a deal of light upon that history and have been accepted by science as a momentous revelation. The history of our earth is not a less important knowledge than that of the races of men who have inhabited it. And how can it be studied in all its bearings, if we do not take into consideration the physical laws which have governed its atmosphere from the beginning? The plants are the true recorders of atmospheric circumstances, and the fossil plants the documents, the hieroglyphs written and left in the strata of the earth for the interpretation of their laws. They have recorded them as clearly as it is done by the instruments used now, the thermometers, the barometers, the hygrometers, etc. Shall we not open the great book and try to read at least some of its pages, though they may have become obscured by the walk of time? And as all animal life depends on plants, the concordance of the development of both the vegetable and animal worlds, should not be forgotten when we come to consider the advantages which may be derived from the study of the coal flora of America. For, of course, these advantages cannot be derivable in such plenitude from an acquaintance with the vegetation of a single country. What has been discovered in Europe, from paleontological evidence, has to be either confirmed, or perhaps, presented under a new light, by what may be found on this continent.

The results of the researches on the remains of coal plants in this country, as far as they have now reached, may be already accounted creditable and valuable. They have proved the existence of land vegetation, as far down as the Upper Silurian period. They have settled the question of the existence of a marine vegetation in the true coal measures, where fucoidal remains, some of them referable to old types, have been discovered in Pennsylvania and Indiana. They have also positively established the fact of the existence of *Fungi* or Mushrooms at the epoch of the coal. But by far the more in-

teresting data procured refer to the discovery in our carboniferous measures of species of plants which have been until now considered in Europe as characteristic of more recent formations. Thus we have in the sub-carboniferous, under the Chester limestone of Illinois, leaves referable to the genus *Glossopteris*, as described by Brongniart, and remarkably similar to those of his *G. Nillsoniana*. This genus, says Schimper, has no analogous in the present vegetation, and its existence appears limited to the first half of the Jurassic period. This is remarkable indeed; and it might be supposed that though the specimens of this species are very clearly defined in their characters, they may represent a different and new type with a mere casual likeness. But we have at Morris, from the first coal above the millstone grit, a fine leaf of *Phlebopteris* (*Dictyophyllum*), preserved in its integrity, with its distinct characters, the peculiar nervation not remarked in any other genus. And this genus is also Liassic, for Europe at least. Beside this, the coal of Morris is related to the Permian of Europe by a number of identical types, a fact remarked already by Schimper. The species of *Spirangium*, for example, are not rare in the nodules of Mazon creek. From the sub-carboniferous of Alabama and of Pennsylvania we have two species of *Tæniopteris*, a genus also considered in Europe as limited to the Permian. This enumeration might be pursued farther; but the peculiarities of distribution will be better understood when accompanied by the description of species, and by the notes upon their relationships.

From the remarks made already it is easily understood that the documents concerning the geographical distribution of the species of the coal flora have been carefully searched for and recorded. They are already valuable for comparing the characters of the vegetation, not only in the different basins in North America, but of Europe also. To elucidate this question as far as possible stations, fixed at distant localities, and where long and persistent explorations have been pursued, are especially valuable. With the station of Newport, Rhode Island; that of Cannelton, Pennsylvania; of Morris, Illinois; of Clinton, Missouri; of Pomeroy, Ohio; of two localities in the coal mines of Alabama, we may expect to find by comparison of the floras reliable documents in regard to the question of the horizontal or geographical distribution of the species.

The last and more important question refers to the stratigraphical distribution of the coal plants; and to it belongs, as a postulate, that of the possibility of determining the relative horizons of the coal beds from the vegetable fossil remains possibly discovered in connection with them. This question has been for a long time, and is still, at issue among European paleontologists, who are generally inclined to admit that there is or should be a marked diversity in the floras of coal strata of different ages or of different horizons. Imbued with this persuasion I began researches in Pennsylvania with the idea that in a fair and open field like that of our carboniferous measures, which are exposed to exploration, sometimes for great thicknesses of strata, and besides, over very wide areas, a problem of this kind should be easily solved. My belief in the applicability of paleontology

to the identification of the coal beds was confirmed by the opinion of the miners, who, when questioned on the subject, generally asserted that it was for them an easy matter to tell one coal from another by comparing the roof shales, and their remains of plants. My first attempt to a determination of this kind, in connection with the first Geological Survey of Pennsylvania, was, as observed by Professor Lesley, a marked failure. For I considered the Salem vein of Port Carbon as the equivalent of the Mammoth, while these represent the two extremes of the Anthracite measures, one at the base, the other in the upper part. But paleontology is not accountable for a personal blunder, which, moreover, was forced upon me by peculiar circumstances which, if they do not make it excusable, at least explain it. I had found, back of the hill facing Port Carbon, just after passing the cut of the railroad entering Mill creek, large heaps of shale extremely rich in fossils, and had there made a prolonged search for the study of a well determined local flora, when I was informed by a miner that I should find opposite, and at the foot of Sharp Mountain, the same kind of shale with abundant specimens of the same plants. There, indeed, I found *Pecopteris arborescens*, an essentially characteristic species of the upper coal, with *Neuropteris Loschii*, and other species seen at the first locality ; but with them were remains of *Lepidodendron*, of species of *Sigillaria* and of *Alepthopteris*, which I had formerly recognized above St. Clair, in connection with the Mammoth vein. This seemed so extraordinary that I visited the same places many times on the supposition that I had been mistaken by false appearances in the characters of the plants ; but the same evidence was always there ; and I came to the conclusion that from all appearances, that coal of Port Carbon was the equivalent of the Mammoth, though differently placed by Professor Rogers. For all the coal beds along the valley of Mill creek are turned up vertically, and therefore, their relative position was at that time unascertained. It was only after years, that in my rambles around Pottsville, on revisiting again the heap of shales of Sharp Mountain, I was informed by the Superintendent of a coal mine whom I met in the vicinity, that these debris were from a tunnel pierced through a number of small veins including the upper ones, to reach the bottom vein, the Mammoth, which was found there too thin to be worked and had been abandoned. Therefore the remains of plants of a number of coal beds of different horizons were there mixed together. I do not say this in order to support an opinion which, in regard, at least, to the application of vegetable paleontology to the identification of coal strata, has been, by long experience, if not altered, at least reduced in the main. For I know well, now, how rarely remains of fossil plants are found in the same degree of profusion in connection with coal beds of the same horizon ; how rarely, when these remains are found, they represent the same species, or, at least, have them in the same proportional distribution ; and how careful and protracted the study of the flora of the same coal has to be before it is possible to know the peculiar species which may belong exclusively to it, or be considered as the leading ones. For this

knowledge includes, with the acquaintance of the greatest number of species recognized at a peculiar locality, that of their mode of dispersion over wide areas, or of the changes caused locally by the geographical distribution of the species. When the coal beds are, therefore, at great distances, it is not possible to leave off the idea that the modifications in the characters of the plants, if differences are observed, may have been caused as well by local synchronous influences as by a difference in the time of their formation or in their age. Nevertheless, I still believe that in basins of limited areas or for beds of coal of one and the same locality, the remains of plants in the roof shale may serve to identify the different strata, and may thus be used as a direction by the miners. But even in such cases the paleontological indications may fail or lead to mistakes; for the changes in the constituents of the roof shales are often sudden and remarkably varied. The Cook vein of Western Kentucky, for instance, has in its shale a profusion of remains of *Lepidodendron* and *Lepidostrobi* on one side of the main gangway, while on the other it is transformed into a kind of compact bone or cannel coal with no other fossils but small shells.

When the subject of the vertical distribution of the vegetation of the coal is considered *a priori*, it seems rational to admit that the same vegetable types cannot have been persistent for such a period of time as was necessary not only for the growth and accumulation of the plants which have entered into the composition of a coal bed from six to ten feet thick, or more, but for the heaping of the intercallated strata, sandstone, limestone, shale, etc., which sometimes measure hundreds of feet in thickness. The study of the floras of our time does not afford us any data in regard to the duration of vegetable types. The human races are still too young, or at least the records of the present vegetation do not yet reach far enough to afford evidence of the modification of any species of plants. We have, however, positive facts in the more recent geological times which prove a remarkable degree of persistence in the characters of a flora for a distance of time, as indicated by interstratified formations, still longer than it may be supposed necessary for the production of two coal beds, and hundreds of feet of shale, sandstone, etc. between them. In the Tertiary of the Rocky Mountains, strata bearing plants in connection with lignites have been found at Point of Rocks, Wyoming Territory, and a number of identical species, indeed, a flora bearing the same general characters, is exposed, also with lignite beds, at Black Butte, though the two localities are separated by three to four thousand feet of measures, shale, sandstone, lignite beds, etc. If these lignite floras had been considered separately and without evidence of the distribution of the intervening measures, they would have been admitted as evidently synchronous, or as representing the same horizon. Hence the long persistence of vegetable types is a fact which has to be recognized by paleontologists although it may be contradictory to theoretical considerations.

The modifications in the characters of the plants are recognized, however, in the flora of the Carboniferous; but they have been slow, tran-

sitional, and affecting essentially the general features of periods. They give to separate groups a peculiar character, which may serve to separate them. In a lot of plants sent by Prof. Eug. Smith from Alabama, for example, I found such a dissimilarity of typical forms from those of the coal measures of the north, and also such an affinity with those of the Arkansas sub-carboniferous flora, that this relation forcibly referred both to the same period.

The distinctive characters of the groups of the Carboniferous can be only briefly exposed now; but they are to be more positively fixed in the Flora by separate tables indicating all the species of plants which have been recog nized in each of them. This will prove an interesting representation of the distribution of the vegetation of the coal, not merely by the number of species, but especially as a kind of scale marking the progress in the modification either by disappearance of some types, or by their reproduction under different characters.

The groups as recognized until now are the Catskill, or old red; the Pseudo-carboniferous; the Sub-carboniferous, or Vespertine, limited upwards by the millstone grit; the Lower Carboniferous, up to the Pittsburgh coal; and the Upper Carboniferous, above it.

A few species of small Lycopodiaceous plants of the genus *Psilophyton* (Daws), appear first in the upper Silurian, and continue, by modifications of size especially in the Devonian, where four species are recognized. I consider this genus as representing the only Devonian type which does not pass up into the Carboniferous. There may be some others, however, as indicated by fossil wood: *Dadoxylon*, *Syringoxylon*, *Prototaxites*, etc. But the anatomy of the fossil wood of the whole Carboniferous is not yet advanced enough to allow conclusions on the characters of the vegetation represented by fossil trunks. Prof. Dawson is still pursuing with an industrious energy his researches on this difficult subject, which, to my regret, has remained inaccessible to me for want of materials. For except the fossil wood of the Black Devonian shale of Ohio, no specimen of silicified vegetable organism has been discovered in coal measures of the United States, except the numerous stems of fern trees of Southern Ohio. These might give materials enough for the work and studious application of a whole life.

The more notable characteristic type of the Catskill group is that of the ferns described first under the generic name of *Nœggerathia*, and more recently of *Palæopteris* and *Archæopteris*. The species are represented by large fronds; those of the older type with simple leaflets more or less enlarged upwards from a narrowly cuneate, somewhat decurring base, whose veins are straight and diverging, fan-like, merely by sub-divisions. The forms of the leaflets are very variable; some appear nearly linear and merely thinly lined with parallel veins. These, however, pass to the genus *Cordaites*, which is present in the whole flora of the coal measures. The modifications of *Psilophytum* are possibly represented in the Catskill by a few species of *Lepidodendron*. *Calamites*, *Annularia* and *Asterophyl-*

ites have there, also, some rare representatives. In the Pseudo-carboniferous, characterized as it is now by the species published by Prof. Andrews, from the Waverly Sandstone of Ohio, and those determinable from the specimens from Port Byron, Ill., the *Palæopteris* continues to be present. But some of the species have lobed or decomposed leaflets, tending by these characters to a section of the *Sphenopteris*, which comes later. The predominant forms are those of *Megalopteris*, a splendid fern whose advent is not prefigured in the flora of the Catskill by any species known until now. But in its large leaflets and its nervation, it evidently betokens the great family of the *Neuropterideæ* to which belong the most beautiful and varied forms of the coal plants. The same rock group has rare species of *Alethopteris*, also with very large fronds and leaflets, *Hymenophyllites*, and broadly winged fruits of the genus *Cardiocarpon*. One species of *Palæopteris*, similar to *P. obtusa*, is remarked in this division as well as in the Catskill group. And on another side it has some species of *Lepidodendron*, *Lepidophloios*, a small *Asterophyllites*, etc., which continue higher up, and enter the sub-carboniferous measures. We have as yet too little data in regard to the flora of the Catskill, and that of the Pseudo-carboniferous to be able to positively recognize the points of affinities and of difference. Most of the species have been described from Canada and Maine, and their age generally ascribed to the Devonian, or marked under the indefinite appellation of pre-carboniferous. The flora of the sub-carboniferous division is, *per contra*, known by a large number of its species. It is allied to the pseudo-carboniferous by those which are named above; by species of *Sphenopteris*, *Triphyllopteris*, *Eremopteris*, and especially of *Alethopteris*, of analogous types. It has for its own predominant characters some *Neuropteris*, with large fronds and small leaflets as *N. Smithii*, which though extremely abundant in Alabama and Virginia, has not as yet been discovered in the coal measures above the Millstone grit; *Neuropteris tenuifolia*, which persists even to the highest strata of the coal, is there also. Professor Fontaine has seen in the Vespertine of Virginia species of *Odontopteris*, a genus predicted by the fine *Eremopteris marginata* of the pseudo-carboniferous. This one partakes of the *Odontopteris* type, quite as much as of the *Eremopteris* character, recalling also something of the facies of *Megalopteris*, which has not been seen in the sub-carboniferous until now. In this last division, the number of species is, as stated, greatly multiplied, and it becomes now difficult to positively mark those which are limited to it. The *Lepidodendron*, especially, are extremely abundant. The old types *L. Sternbergii*, *L. Veltheimianum*, *L. aculeatum*, etc., appear mixed with more recent ones, and with others which seem peculiar to this division: as *L. squamiferum* from the Helena vein of Alabama, which bears upon its bark true scales, easily detached, and at the same time, the scars of leaves generally remarked upon the trunks and branches of *Lepidodendron*. The collateral genera are represented also: *Ulodendron*, *Halonia*, *Lepidophloios*, *Knorria*; *Stigmaria* is there in abundance, though remains of *Sigillaria* are as yet extremely rare. Among the

species which have been considered in Europe as characteristic of the Mountain Limestone of the culm, we have in the sub-carboniferous of Alabama and Virginia *Alethopteris nervosa*, *A. muricata*, and *Sphenopteris Hœninghausii*, this as common in the shale of the Helena coal as *Neuropteris Smithii*. These three species, however, ascend in the American coal measures to above the Millstone grit, which, though a kind of geological delimitation, as well traced here as in Europe, is not a very definite line of demarcation between the vegetable groups. For, with few exceptions, the lower carboniferous flora has still the types of the sub-carboniferous, merely modified, and represented by an increased or diminished number of species. The lycopodiaceous are still more abundant ; and we have, especially in the lower veins, immediately above the Millstone grit, the largest number of species of *Lepidodendron* and *Ulodendron*. *Stigmaria* and *Sigillaria* have gained in predominance; and in the ferns, new species of *Neuropteridæ*, especially some large-leaved *Neuropteris* and *Odontopteris*, are seen for the first time. The wide-ranged *Alethopteris Serlii*, and its analogous species *A. lonchitica*, are there also ; the first already seen in the sub-carboniferous, the second a derivation of *A. Helenæ*, of the same lower division. *A. Pennsylvanica* and *A. Sullivantii*, may be counted too in the first coal above the conglomerate, as prefiguring in their more important characters those of the *Callipteris*, which comes later in order of time. For one species of this last genus only is known in the lower carboniferous, and another from the Cannelton coal, already somewhat high up in the measures. As the largest number of the species of plants of the coal have been obtained from the lower carboniferous, it would be possible to continue the enumeration of the species which are considered as proper to it or as characteristic. But subsequent researches may greatly reduce the number; for as yet few strata bearing remains of plants have been discovered in the upper carboniferous. This division may be limited from the base or from the top of the barren measures underlying the Pittsburgh coal; for indeed we know as yet nothing of the flora of these barren strata. In ascending from the Millstone grit, after passing the two first coal beds above it, the vegetation is rapidly modified in its characters by the gradual disappearance of the Lycopodiaceous types, and the increasing predominance of the ferns. The species of *Sigillaria* continue in about the same proportion ; *Annularia*, *Sphenophyllum*, *Asterophyllites*, become more abundant. And while some of the generic divisions of the ferns, like *Alethopteris* and the large-leaved *Pecopteris*, seem to pass away; the group of the *Cyatheæ*, represented by *Pecopteris arborescens*, *P. oreopteridia*, *P. polymorpha*, etc., become the more numerous, and especially characterize the upper carboniferous. They mostly belong to tree ferns, which, besides the extreme abundance of their pinnæ in the highest veins of Pennsylvania, have left, petrified in the sandstone of Ohio and Virginia a prodigious quantity of trunks representing whole forests. With these there is no trace of *Lepidodendron* ; some *Sigillaria* are left. The vegetable world was at that period a world of ferns, mixed with the *Cordaites*, a race of as yet undetermined relation, it seems, half-lycopodia-

ceous, half conifers. These plants are mostly known by their long linear, ribbon like leaves; their stems have been very rarely found. Some large, bushy species of *Neuropteris* have persisted. *N. hirsuta* and *N. Loschii* ascend from the Millstone grit to the Permian. And above the Pittsburgh coal or even in connection with it are found the *Callipteris*: *Callipteris Moorii*, and *Callipteris conferta*, this last species one considered in Europe as Permian, and found by the Virginian geologists, Fontaine and White, in the highest strata of the carboniferous. We have seen, however, that many other so-called Permian types are remarked in the American coal measures already from below the millstone grit; and therefore, it is not as yet advisable to consider as Permian those upper strata which, beside this *Callipteris*, have a number of representations of truly carboniferous species.

It remains only to state how far the work on the American coal flora has progressed towards its completion. The plates, sixty in number, are all ready. The number might be still further increased by several species which cannot be clearly represented by descriptions only; but wood cuts may be used for the purpose, if it is advisable and possible to have any intercallated into the text. The description of the species and the remarks upon their diversified characters, as seen in the comparison of the specimens, have been all written, and, therefore, the manuscript may be definitely prepared in a short time. It is, however, not yet in its final shape, as the records have to be left open for the admission of any valuable data which the continued communications of materials may bring to the Flora.

This synopsis is very incomplete, but it cannot be made comprehensible without the tables of distribution, even if a large number of species were enumerated. Moreover the limitation of the vegetable groups is not yet definite enough. New and indeed very desirable discoveries, especially of plants of the Lower Carboniferous, the Vespertine of Pennsylvania, and the Devonian Hamilton Coal Measures of the Juniata, may compel important modifications. Therefore, the divisions as marked above, as well as their names, should be considered only temporary. They are subject, of course, to geological evidence which ought to govern them. The final nomenclature of the groups of the "Coal Flora" must accord with that of the Second Geological Survey of Pennsylvania.

Tabular Synopsis of the Rhynchophora of America.

(See Minutes of January 5, 1877.)

Dr. Le Conte presented a tabular statement of the number of species of Rhynchophora, contained in the XV. volume of the Proceedings of the Society, and their geographical distribution in the different zoological provinces of temperate North America. He mentioned the instances in which the occurrence of similar extraordinary forms in geographical regions very remote from each other corresponded with what he had previously shown in the other higher types of Coleoptera, and again expressed the opinion that the isolated and feebly represented, though sometimes widely distributed forms in insects were representative survivals of the faunæ of former geologic periods; and proceeded:

It is useless to oppose this view by the statement that these composite, synthetic, prophetic or undifferentiated types have not yet been found in the strata, for every well-informed entomologist will remember that except in Tertiary strata but few localities have presented specimens sufficiently preserved to permit accurate study. Moreover the localities thus far explored are all in the temperate zone, where we may reasonably not expect to find the predecessors of the larger and more conspicuous forms.

In the older rocks the insect remains are so compressed, and the sutures of the most important elements of the external skeleton so obliterated, that but little knowledge can be had except from the venation of the broad winged orders. In this respect there is, as I can state from information furnished me by Dr. Hagen, a striking correspondence between some of the Carboniferous lace-winged insects and our own existent *Pteronarcys*.

But in fact, *Pteronarcys*, being peculiar, among all genera of similar form and appearance, by possessing in the adult distinct remnants of the larval branchiæ on the anterior segments of the abdomen, would necessarily, by my method of interpreting structures, be regarded as a survival of an ancient form, even if no *Miamia* wing had been found in the coal quarries.

A better appreciation of the characters of resemblance, which ally the more important groups represented at present in the various classes of animals, as contrasted with the differences between them and their analogues of former periods, the remains of which are found in the rocks, and which are occasionally represented by survivals of insignificant size or restricted area, will enable entomologists to take broader views of the capabilities of the branch of science which they cultivate; but in which too often their attention is directed to squabbles about nomenclature, orthographic or historical, and to the simple enlargement of our knowledge by the description of generic and specific forms.

Tabular Synopsis and Geographical Distribution of Families, Subfamilies, north of Mexico, by J. L. Le Conte, assisted by George H. Horn, and XV, No. 96. (*See Minutes of January* 5, 1877.)

NAME. FAMILY. SUBFAMILY. TRIBE.	NUMBER.					
	GENERA.			SPECIES.		
	Descr.	New.	Total.	Descr.	New.	Total.
I. RHINOMACERIDÆ.	1		1		4	4
II. RHYNCHITIDÆ.						
i. Rhynchitidæ.	3		3	10	11	21
ii. Pterocolidæ	1		1	1		1
III. ATTELABIDÆ	1		1	4	1	5
IV. BYRSOPIDÆ	1		1	1?		1?
V. OTIORHYNCHIDÆ.						
1. Brachyderini.	4	5	9	6	5	11
2. Ophryastini.	6	12	18	13	13	26
3. Otiorhynchini.	7	11	18	19	23	42
4. Dirotognathini.		1	1		1	1
5. Tanymecini.	4		4	4	3	7
6. Cyphini	5	3	8	5	8	13
7. Evotini.	2	1	3	1	2	3
8. Phyllobiini	2	2	4	2	3	5
9. Promecopini.	3		3	4	1	5
VI. CURCULIONIDÆ						
i. Sitonidæ.	1		1	8		8
ii. Alophidæ	1	5	6	7	4	11
iii. Ithyceridæ.	1		1	1		1
iv. Curculionidæ.						
1. Phytonomini.	4		4	24	19	43
2. Emphyastini.	1		1	1		1
3. Hylobiini.	5	2	7	13	2	15
4. Cleonini	3	3	6	16	25	41
5. Erirhinini	13	6	19	22	48	70
6. Trachodini.	1		1	3		3
7. Otidocephalini	1		1	7	1	8
8. Magdalini	1		1	12	4	16
9. Anthonomini.	2	3	5	17	34	51
10. Prionomerini.	2		2	2	1	3

Tribes, Genera, and Species, mentioned in the Rhynchophora of America, published in the Proceedings of the American Philosophical Society, Vol.

DISTRIBUTION.						COMMON TO OTHER CONTINENT.	
GENERA.			SPECIES.				
Atlantic.	Central.	Pacific.	Atlantic.	Central.	Pacific.	Genera.	Species.
1		1	2		3	1	0
3	2	2	12	5	6	3*	0
1			1				
1	1		4	2		1	0
1	1		1?	1?			
3	3	4	4	4	4	1	1
7	2	12	11	2	14		
3	12	6	4	25	14	3	5
		1			1		
3	2		6	2		1	0
5	4		6	9			
1	2	1	1	2	1		
4		1	4		1	2	1
3	1		3	2			
1	1	1	3	1	4	1	5
1	2	6	1	3	8		
1			1				
4	4	4	33	5	6	2	3
		1			1	*	
6		2	13		3	3	0
3	6	3	14	19	13	3	0
17	9	11	47	16	20	8	4
		1			3	1	0
1	1	1	6	1	1		
1		1	8	2	7	1	0
4	4	4	39	6	12	2	
2			3				

NAME. Family. Subfamily. Tribe.	NUMBER. Genera. Descr.	New.	Total.	Species. Descr.	New.	Total.
11. Tychiini	2	6	8	1	15	16
12. Cionini	4		4	3	1	4
13. Derelomini		1	1		3	3
14. Læmosaccini	1		1	1		1
15. Cryptorhynchini	8	8	16	34	45	79
16. Zygopini	2	1	3	4	9	13
17. Tachygonini	1		1	2	2	4
18. Ceutorhynchini	6	3	9	15	24	39
19. Barini	2	15	17	40	44	84
20. Hormopini		1	1		1	1
v. Balaninidæ	1		1	6		6
VII. Brenthidæ						
i. Brenthidæ						
1. Arrhenodini	1		1	1		1
2. Brenthini	1		1	2		2
ii. Cyladidæ	1		1	1		1
VIII. Calandridæ						
i. Calandridæ						
1. Rhynchophorini	1		1	2		2
2. Sphenophorini	3	3	6	33	4	37
3. Calandrini	1		1	3		3
ii. Rhinidæ		1	1	1		1
iii. Cossonidæ						
1. Dryophthorini	3	1	4	2	2	4
2. Cossonini	5	2	7	13	1	14
3. Rhyncolini	7		7	11		11
IX. Scolytidæ						
i. Platypodidæ	1		1	5		5
ii. Scolytidæ						
1. Tomicini	10	1	11	56	13	69
2. Scolytini	1		1	6	3	9
3. Hylurgini	11	3	14	35	7	42
X. Anthribidæ						
1. Tropiderini	3	5	8	3	7	10
2. Basitropini	5	3	8	10	8	18
3. Araeocerini	2		2	1	2	3
4. Xenorchestini	1	1	2	1	1	2
XI. Apionidæ	1		1	22		22
	161	109	270	517	405	922

DISTRIBUTION.						COMMON TO OTHER CONTINENT.	
GENERA.			SPECIES.				
Atlantic.	Central.	Pacific.	Atlantic.	Central.	Pacific.	Genera.	Species.
5	1	3	10	1	5	2	0
4			4			4	3
1			3				
1			1				
13	5	5	65	11	8	3	0
3	1	2	9	3	5		
1	1		3	1		*	
9	3	3	31	5	9	7	4
14	9	6	71	20	10	?	
1			1				
1	1	1	6	1	1	1	0
1	1		1	1			
		1			2		
1			1			1	0
1		1	1		1	1	0
2	4	4	21	25	13	1	0
1	1	1	3	1	1	1	2
		1			1		
4	1		4	1		1	0
6	1	2	13	1	3	4	0
5	1	3	6	1	6	5	0
1		1	4		1	1	0
10	3	7	47	7	27	6	0
1	1	1	4	1	5	1	0
12	4	9	25	6	21	7	0
6	1	3	7	1	3	1	0
8	1		17	1		2	0
2		1	3		1	1	1
2			2			1*	0
1	1	1	13		9	1	0
163	98	118	591	194	255		

Remarks:

I. This family consists of but one genus; one species is found in Europe; all others known occur in our fauna.

II, i. Rhynchites is cosmopolitan; Auletes occurs in Europe, and Eugnamptus in Asia. The latter is the most feebly developed of the family, and resembles in its distribution, Othnius and Ischalia of the Heteromera, and tribe Tachygonini (VI. iv, 17), mentioned below.

II, ii Pterocolus is an isolated form, having at present no relationships with other genera, though a feeble resemblance in form to the Ceutorhynchini (VI, iv, 18). If my method of interpretation be correct, there were older genera, by which Pterocolus and Tachygonus were affiliated.

III. Attelabus is cosmopolitan, and seems to be the highest development in the series Haplogastra.

IV. The Byrsopidæ are represented in all zoölogical regions, except Australia; but our genus, Thecesternus, represents an isolated group. From the great differences between individuals, which seem to have unstable specific characters, I am disposed to regard this group as an ancient survival, in the process of evoluting into something else. The variations in the length of the humeral processes of the elytra, and in the sculpture are scarcely explicable, unless we suppose that species formerly distinct are hybridizing. That an ancient type should suddenly effloresce in modern times to produce many species is hardly conceivable, and we should, therefore, be willing to admit, that in this instance the phenomenon is one of absorption, or integration rather than differentiation.

V, 1. *Barynotus Schönherri* occurs in Northern Europe, and is subarctic, and therefore quite capable of being found on both continents.

V, 3. Two species of Otiorhynchus are arctic, and common to both continents; three have been introduced with fruit trees. Mylacus occurs in Europe and Asia, and on our Pacific Coast; Trachyphlœus in Europe, Asia, and in Eastern America.

V, 5. Tanymecus is supposed to be cosmopolitan, but has not yet been properly studied. Of the other genera in our fauna, Pandeleteius and Pachnæus extend to the Northern Tropics of America, and Hadromerus even to Brazil.

V, 6. Cyphus is largely represented in Tropical America, and is conjectured to occur in Asia (*C. chrysis*, Fabr.). The other genera, so far as known, are North American, or extend only into the Northern Tropics.

V, 7. The only described genus of this tribe is Lachnopus, which extends from the Northern Tropics into our fauna. The other genera in our fauna are new, and their distribution is not yet known.

V, 8. One species of Phyllobius has been introduced from Europe into Canada. Scythropus occurs on both sides of the continent, in Europe, and also in Northern Africa.

V, 9. This tribe seems to be exclusively American, and one genus, *Coleocerus*, extends to the Southern Temperate Zone.

VI, i. Sitones is confined to the northern hemisphere; of the eight species in our fauna, five occur in Europe, and of these, but one, *S. tibialis*, can be supposed to have been introduced.

VI, ii. This sub-family is confined to the temperate and subarctic regions of the northern hemisphere; the genera are all different from those recognized on the other continent, though it is quite possible that some of them may be represented in Northern Asia.

VI, iii. Ithycerus is an entirely isolated form, having no relations to other genera, so far as known to me.

VI, iv, 1. One species of Phytonomus and two of Lepyrus are common to the subarctic regions of both continents. Listronotus and Macrops probably extend into tropical America, but a renewed study of the old genus Listroderes must be made before this can be definitely stated.

VI, iv, 2. This peculiar maritime fossorial tribe is represented by a different genus in Australia.

VI, iv, 3. Plinthus, Hylobius, and Pissodes, are confined to the northern hemisphere, but may be represented (*teste* Schönherr) in Brazil and Australia. Hilipus is largely represented in South America, but not on the other continent, unless *H. orientalis* Motsch, from Japan, should on proper examination prove to belong to the genus.

VI, iv, 4. The genera in this tribe are very indefinite, and the foreign species still require revision to bring out the facts in geographical distribution. Lixus, Cleonus, and Stephanocleonus, are the only examples I can mention at present of genera common to both continents.

VI, iv, 5. *Procas picipes*. two species of Grypidius and *Tanysphyrus lemnæ*, are common to the northern part of both continents, and have not been introduced. The only genus which extends to Tropical America is Phyllotrox.

VI, iv, 6. Trachodes is subarctic, and occurs on both continents.

VI, iv, 7. Otidocephalus is peculiar to North and South America.

VI, iv, 8. Magdalis is cosmopolitan, but most largely represented in Europe and North America.

VI, iv, 9 Anthonomus is cosmopolitan, or nearly so. Orchestes is confined to the northern hemisphere. The other genera in our fauna are new, and their distribution is consequently unknown.

VI, iv, 10. This tribe seems to be exclusively American, but both genera extend into the southern tropics.

VI, iv, 11. The tribe Tychiini has not been separated from Erirhinini sufficiently accurately to make any observations of value at present.

VI, iv, 12. I do not know if the species common to Europe and America have been introduced or not. The tribe, by the diminished number of joints in the funicle of the antennæ indicates a low grade, and the genera are widely diffused on the eastern continent, but do not occur in South America or Australia.

VI, iv, 13. This small tribe is represented on both continents; the species have not been studied with sufficient care to indicate the distribution of the genera.

VI, iv, 14. This tribe is American, and best represented in the tropics.

VI, iv, 15. With the exception of Acalles, Cryptorhynchus, and Cœlo-

sternus, which are supposed to be cosmopolitan, our genera are not found on the other continent. These which have been previously described, mostly extend to the southern tropics of America, and of the eight new genera, nothing can yet be said. As a tribe the distribution is general.

VI, iv, 16. Copturus abounds in tropical America, and is feebly represented in tropical Asia. Piazurus is entirely American. As a tribe the distribution is general.

VI, iv, 17. Tachygonus is exclusively American; one species is Brazilian. The only representative in foreign parts is *Dinorhopala* Pascoe, in Burmah.

VI, iv, 18. With closer comparison the number of species common to Europe and the United States may probably be increased. There is but one, *Ceutorhynchus rapæ*, which may have been introduced.

VI, iv, 19. Until a new study has been made of Baris, Centrinus, and allied genera, any remarks upon geographical distribution would be prema'ure.

VI, v. Balaninus, as recorded in the Munich Catalogue is cosmopoli'an; a better study of the foreign species is necessary, in order to know if they possess the essential character of the subfamily; the vertical movement of the mandibles.

VII, i. Our two genera extend into tropical America.

VII, ii. *Cylas formicarius* has probably been imported from Asia, though *Convolvulus batata*, upon which it depredates, is considered an American plant.

VIII, i, 1. Rhynchophorus is cosmopolitan, but confined to tropical and subtropical regions, being parasitic upon palm trees. Sphenophorus is cosmopolitan. Calandra has deen distributed in cereals until it is now difficult to determine whence the species have emigrated.

VIII, iii, 1. Dryophthorus seems to be cosmopolitan, the other genera are local, so far as known at present.

VIII, iii, 2. Cossonus and Mesites are common to both continents; Caulophilus is found in Madera, and Himatium in India. Stenomimus occurs in Brazil, and Homaloxenus in San Domingo.

VIII, iii, 3. Stenoscelis is almost cosmopolitan; Rhyncolus is found throughout the northern hemisphere, and in Brazil; Phlœophagus, Amaurorhinus, and Hexarthrum in the Atlantic Island and Europe; the last named also occurs in Japan.

IX, i. Platypus is cosmopolitan.

IX, ii, 1. Pityophthorus, Xyloterus, Xyleborus, Dryocœtes, Cryphalus, and Tomicus, are common to both continents.

IX, ii, 2. Scolytus is widely diffused on both continents.

X, 1. Tropideres is the only genus occurring on the other continent.

X, 2. Anthribus and Brachytarsus are represented in Europe.

X, 3. Choragus also occurs in Europe. Araeocerus is cosmopolitan, and distributed in articles of commerce.

X, 4. Xenorchestes has been found only in Madeira.

XI. Apion is cosmopolitan.

On Refraction Tables.

By A. K. Mansfield, Cordova, S. A.

(*Read before the American Philosophical Society, January* 5, 1877.)

The operation of computing the difference between the true and the apparent zenith distances of stars, is usually performed by means of Bessel's refraction tables, which are calculated from his formula, namely :

$$R = d\ tan\zeta\ (BT)^{A}_{\gamma}{}^{\lambda}\ *$$

This operation is usually logarithmic, and the refraction tables are therefore tables of logarithms. The computation may, however, be very much simplified, by the use of natural numbers in place of their logarithms, as will appear from the following :

In the above formula substitute R for $d\ tan\zeta$, and ρ for $(BT)^{A}_{\gamma}{}^{\lambda}$. The formula then becomes

$$R = R_1 \rho \ldots\ldots\ldots\

In making the table, comparatively few values need be computed, for, having these few values, the others may be supplied by interpolation. The following is a small portion of a table of these corrections, in what appears to be its most convenient form. It was computed from Bessel's tables, as given by Peter's.

log. ρ	—0.01000	1100	1200	1300	1400	1500	&c.
ζ	Mean R.						
15°	15.12	0.03	0.07	0.10	0.14	0.17	
	106						
16	16.18	0.04	0.08	0.11	0.15	0.19	
	107						
17	17.25	0.04	0.08	0.12	0.16	0.20	
	108						
18	18.33	0.04	0.09	0.13	0.17	0.21	
	110						
19	19.43	0.04	0.09	0.13	0.18	0.22	
	111						
20	20.54	0.05	0.10	0.14	0.19	0.24	
	112						
21	21.66	0.05	0.10	0.15	0.20	0.25	
	114						
22°	22.80	0.05	0.11	0.16	0.21	0.26	
log. ρ	—0.01000	.00900	0801	0702	0604	0505	&c.

Apparent zenith distance is here used as argument at the side. It may be replaced, however, by the corresponding declination, or the circle reading. *Log.* ρ is used as argument at the top, and —0.01000 is the assumed value of *log.* ρ_o. When *log.* ρ = *log.* ρ_o the correction is zero, therefore we have written the table of mean refractions in that column, thus combining both tables in one. This may be done when the arguments at the side are not chosen so far apart as to make the second differences of the mean refraction too great. In computing the tables from the above formulæ, the *arithmetical complement of log.* ρ must be used, when that *log.* as found from Bessel's tables, is negative. When *log.* ρ occurs in the line at the top of the table, the correction is negative, when in the line at the bottom, it is positive. To find the values of *log.* ρ for the lower line, corresponding to those of the upper line, call the natural number corresponding to any particular value in the upper line ρ_1, and its corresponding value for the lower line ρ_2. Then from formula (3), since r is minus in one case and plus in the other,

$$-\rho_1 + \rho_o = \rho_2 - \rho_o$$

$$\text{or } \rho_2 = 2\rho_o - \rho_1 \quad \ldots\ldots\ldots\

plied to the log., and when 77° or more, another correction must be applied on account of the exponent A. These corrections may be found as follows :

Let $log.\ \rho_1 = log.\ (BT) + log.\ \gamma$, then the entire correction

$$r_1 = log.\ \rho - log.\ \rho_1 = log.\ \gamma\ (\lambda - 1) + log.\ (BT)\ (A - 1) \ldots . (5)$$

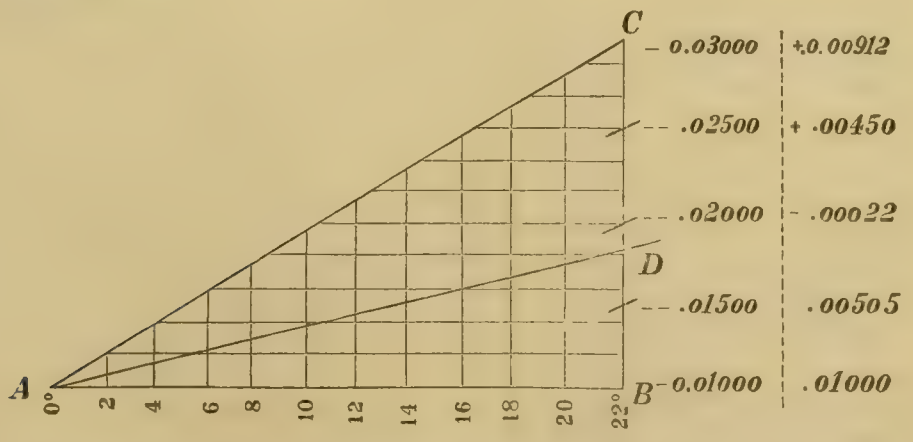
in which the two terms of the last member are the first and second corrections respectively. The following will illustrate a method of tabulating these corrections :

ζ	0.01000	2000	3000	4000	ζ
60°	5	9	14	18	80° 40′
61	5	10	15	20	81 0
62	5	11	16	22	81 30
63	6	12	17	23	81 50
64	6	13	19	25	82 10
65°	7	14	20	27	82° 30′

The argument at the top is either $log.\ (BT)$ or $log.\ \gamma$, according to which correction is sought for. The side arguments are zenith distances, which may be replaced by declinations, &c.

The first column is used when taking out the first correction, and the last column, when taking out the second correction. To find the values of the argument for the last column, enter Bessel's table "A" with the value of λ for any zenith distance of the first column, and against it will be found the corresponding zenith distance for the last column. The units place of the corrections, corresponds to the fifth place of $log.\ \rho$, and when the logarithmic argument is negative, the correction is negative, and *vice versa*.

In place of the above table of corrections to mean refraction, a graphical table may be constructed, which has some advantages. Let a right-angle triangle $A\ B\ C$ be drawn, containing lines parallel to the base, at equal distances apart.



These equal distances may represent seconds, or tenths of a second. The distance $B\ C$ is made equal to the maximum correction rm, or the correction for the maximum zenith distance, and maximum value of $log.\ \rho$, which

occur in the table. Values of r are now computed for the different values of the argument $log.\ \rho$, but for the maximum zenith distance, and the results laid off on the line BC, from the point B; and against the points thus found the arguments $log\ \rho$ are written. Along the line AB are written the zenith distances. Equal increments of zenith distance are represented by unequal increments of the line AB, in order that the line AC, or line of maximum corrections, may be a straight line. Call the co-ordinates of any point of AC, d and r, and the distance AB, dm. Then

$$d : dm = r : rm$$

$$\text{or } d = \frac{dm}{rm} r = \frac{dm}{rm} R_1 (\rho m - \rho_0) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

from which the distances of the arguments from the point A may be determined. The line AD represents the edge of a ruler, or a thread, stretched from a needle at the point A. If this line be turned about A, until it passes through that point BC, corresponding to the value of $log\ \rho$ for which the correction is sought, the correction will be the length of the perpendicular to AB, measured to its intersection with AD, at the point corresponding to the given zenith distance.

This method has the advantage that the interpolations are made separately, and will undoubtedly give good results, if the diagram is drawn carefully, and large enough.

On the First Systematic Collection and Discussion of the Venango County Oil Wells of Western Pennsylvania. By E. S. Nettleton, C. E. Prepared for publication and communicated by John F. Carll, Assistant Geologist in charge of the Survey of the Oil Regions.

(*Read before the American Philosophical Society, January* 19, 1877.)

In the fall of 1868 the first systematic attempt was made to ascertain the direction and dip of the Oil Sands of the Venango region and the true relation which the oil producing rock of one district bears to that of another.

This was during the great Pleasantville oil excitement, when, probably for the first time, the attention of a large class of operators was called to the fact that there was a marked difference between the oil and oil sand of Pleasantville and surrounding districts, and the oil and oil sand of Oil Creek.

Previous to that time very few levels had been taken, and those only locally from well to well on the same farm, or within the bounds of one producing centre; but some of the detached districts had been fortuitously connected by lines of levels run for pipe lines from station to station, and by preliminary Railway surveys which crossed the country in almost every direction. From these sources it was ascertained that the Pleasantville oil rock, although called the 4th sand, lay at a higher elevation than the 3d sand of Oil Creek.

Some operators held the opinion that the oil rocks ran horizontally under the whole country, and that by drilling deeper at Pleasantville, the Oil Creek 3d sand would be found, and a much larger supply of oil obtained. Others contended that the rocks dipped towards Oil Creek and the Pleasantville wells had already reached the Oil Creek sand. They went still further, and pointing to the old failures in the Pleasantville district, averred that there was no oil in the rock when these wells were put down, but that the flooding of the oil sands under the valley of Oil Creek, by the abandonment years before of so many wells, had forced the oil from its original home there to these higher portions of the rock.

Discussions on these points showed the necessity for more information on the subject; and while some chose to gain this information on their own account, by sinking wells deeper at considerable expense to see what might be below, a few believed that something could be learned by a careful study of the wells already drilled, in connection with a series of surface levels extending over a large area, embracing in one system all the main oil-producing centres.

As an outgrowth of this idea an informal meeting was held and a committee appointed to plan and carry out the work necessary to be done. Mr. E. S. Nettleton, then residing in Pleasantville, consented to act as one of the committee, and to undertake the task of running the lines of levels and collecting the well records. A circular was issued to well owners, and

blanks were prepared for filling in the well records, of which the following are copies :

Circular A. Pleasantville Pa.....1868.

Dear Sir:—A pressing need has long been felt by the more thoughtful operators in the Pennsylvania Oil Regions for a more thorough and accurate knowledge of the thickness, dip and general characteristics of the Oil-bearing Rock in this section. The drillings in different localities have established data sufficient for operations in those particular places, but no effort has been made to connect these together in one comprehensive whole, and very little is known as yet of the *relative* positions of the Oil-bearing Rocks in these several localities. In order that this want may be supplied a fund has been raised, a committee appointed to supervise the work, and the services of a competent Engineer secured. It is proposed to make *an accurate topographical survey of Pleasantville, Enterprise, Bean Farm, Pithole, Shamburg, Bull Run, and Pioneer Oil Districts,* and then by a comparison of the records of a large number of the most prominent wells in said districts, to prepare and publish a report, which we think will contain facts and figures of great value to those engaged in the development of Oil Territory. In furtherance of this object the enclosed series of questions have been prepared which we hope you will be so kind as to fill out and return to us,—and any further information you may be able to give will be duly acknowledged.

Signed S. Q. Brown, George K. Anderson, J. H. Hebert, John F. Carll, E. S. Nettleton, Committee.

Address all letters to E. S. Nettleton, Civil Engineer, Box 45, Pleasantville, Pa.

Circular B. Pleasantville, Pa.....1868.

Dear Sir :—Please fill out the following blank and mail to E. S. Nettleton, Civil Engineer, Box 45, Pleasantville, Pa.

Record of.....Well No.....
Located on.....Farm.
Lease No.....Tested.....186..
Distance from surface to top of First or "Mountain" Sand, No. of feet.....
Thickness of the First Sand, " .....
Distance from surface to top of Second Sand, " .....
Thickness of Second Sand, " .....
Distance from surface to top of Third Sand, " .....
Thickness of Third Sand, " .....
Distance from surface to top of Fourth Sand, " .....
Thickness of Fourth Sand, " .....
Distance from surface to top of Fifth Sand, " .....
Thickness of Fifth Sand, " .....
Distance from surface to Sixth Sand, " .....
Thickness of Sixth Sand, " .....
What is the entire depth of your well? " .....

At what depth were the mud veins? No. of feet.....
At what depth is the seed-bag? " .....
How far is the bottom of working chamber from the bottom of the well? " .....
Is your well cased? .....
Quality of the Oil-bearing Rock, Pebble or Sand? .....
What color of oil is produced? .....
Gravity of oil? .....
What has been your best production per day? ..Bbls.
How many engines would the best flow of gas run? .....
What is the Engineer's number of this well as marked on the Samson Post? .....
Remarks:.....

During the winter of 1868–9, the work was prosecuted with considerable interest and diligence, but like all other matters not directly personal, it soon began to be neglected by the committeemen who were all deeply engaged in their own affairs, and Mr. Nettleton was left to work out the problem as best he could, almost alone.

Meantime the field widened. New developments at Scrubgrass and Parker's Landing led off to the south, far beyond the limits proposed for our work. Mr. Nettleton had been attracted to the west, and connected himself with the Engineering Corps of Greeley Colony, which made it necessary for him to close up his affairs in the Oil Regions, preparatory to his removal. No one had any personal interest in continuing the investigation, and the work stopt just when it should have been carried forward, leaving the materials in hand in such an unfinished and incomplete condition that no report could be made which would be at all satisfactory to those who had subscribed to the funds for the Survey.

This was in the Spring of 1870. Mr. Nettleton before leaving Pleasantville, placed all the accumulated papers of the Survey in my hands, where they have remained to the present time. They were accompanied by the following brief report to the Committee, dated Pleasantville, April 1, 1870, and addressed to the Committee of the Topographical Survey :

Gentlemen :—I herewith present to you the facts and papers relating to the Survey which I commenced over one year since.

Levels have been carried to nearly all the important producing centres of the upper district, but I have not been able to connect Parker's Landing with the survey in consequence of its distance from my nearest "bench" at Venango City. I expected to have obtained the elevations along the Allegheny Valley Railway from its Chief Engineer, but have been disappointed.

Many difficulties have been encountered in getting information from well owners on whom I am entirely dependent for the data so essential to this work. Some are not willing and prompt in assisting in this way because they are under the impression that it is a private enterprise ; but the most serious obstacle met with is the characteristic indifference of the people

in the oil business to anything but that which promises an immediate personal benefit.

By means of the levels taken to the well mouths I have adjusted the records of one hundred and thirty-four wells in such a way that they all may be compared with one point. This point is the Ennis Well, Pleasantville, which is located on the highest ground in the county. All other wells are therefore below this base. The elevation of this point above tide I at first determined from information furnished me by the Smithsonian Institution to be 1761.81 feet. This result was aimed at by correcting my own levels with the levels of the Allegheny Valley Railway as I received them. But upon checking my line with other Railway Surveys, I find an error of about fifty-three feet, which I have traced to the Allegheny Valley Railway, between Venango City and Pittsburgh. This makes my base 1709 feet above tide instead of 1762 as first announced.*

In the arrangement of the strata of sandstone I have paid but little attention to the usual method of numbering, which, from the way of counting from the top is very liable to confuse, as in some places two or three mountain sands are found, and in others the first sand is the oil producing rock. I have discarded some records which were evidently incorrect, and have been forced to use some which are not altogether to be relied upon.

I have noted the elevation of 308 wells and about 80 permanent benches in different localities. I also give you the elevation above sea of several places in the western part of the state.

There have been sent out 153 blanks which have not been returned.

I have great confidence in this method of locating and defining the oil-bearing rocks, and from the data which I hand you very much can be gathered which is of practical use.

In the early part of my observations on this Survey I formed the opinion that the oil rocks dipped uniformly in one direction, but more extended surveys show differently. In some places the line of greatest dip is nearly south, while in others it is more westerly. The line of oil deposit lies almost invariably in the line of greatest dip, showing doubtless that the formation was made in swift running water, and the deposit of pebbles was in the line of the current. Hence, the "belts," which correspond with the dip.

If, in your opinion, this Survey is of any practical benefit I would suggest that it be put into the hands of the Producers' Association, with a view of making it to the interest of a larger number to assist in collecting the necessary data.

Much more work is yet required to define and locate the oil-bearing rocks in this section of the State, but the difficulties above mentioned and the lack of co-operation, together with demands on my own time which make it impossible for me to give it the attention required, have induced

* Many efforts have been made in 1874, '5 and '6 to discover the cause and quantity of this error but without the best success, although progress has been made towards its adjustment. [J. P. L.]

me to make this report and place in your hands, to use as you may deem best, all of the facts and figures thus far collected.

No part of the result has been made public, except a small sketch furnished to Dr. J. S. Newberry of the Ohio State Geological Survey.

All of which is respectfully submitted.

E. S. Nettleton, C. E.

Since my connection with the Second Geological Survey of Pennsylvania I have found these papers of great service, and been obliged to refer to them often for facts which could not now be otherwise obtained, but I did not feel at liberty to use the materials in any public way without Mr. Nettleton's consent and the acquiescence of the State Geologist. These restrictions are now removed by Mr. Nettleton's permission to publish whatever may be of general interest.

The well records are many of them imperfect, none of them indeed are just what the geologist requires, for they give no indication of the character of the strata between the Sandstones. The blanks were not prepared with a view of studying the lithology further than it was involved in an examination of the oil rocks. But they accomplished the purpose intended and brought out the facts required to demonstrate that there are different beds of sandstone lying at different horizons and all dipping with considerable uniformity to the southwest.

This may be shown in a general way by taking a few wells at random along the line surveyed from Pleasantville to Oil City—thus : (refer to the records)

(1) Ennis Well, Pleasantville, top of oil sand above ocean		.....807 feet.
(87) National, No. 2, 1½ mile southwest of Pleasantville		.....779 "
(127) Fink, No. 12, Shamburg		.....724 "
(231) Porter, Foster Farm, Oil Creek		.....678 "
(213) G. K. Anderson, No. 134, Pet Centre	True	.....631 "
(258) Lady Suffolk, Blood Farm		.....588 "
(261) Well No. 23, Rynd Farm	3d	.....568 "
(268) Champion, No. 2, Rouseville	Sand	.....557 "
(269) Elizabeth, Clapp Farm		.....545 "
(270) Siveily & Gardner, Allegheny Run		.....522 "

Between the National well and Fink, No. 12, there is a drop of about 45 feet in the figures here given from the Black oil rock or Stray, to the Green oil rock or 3d sand of Oil Creek, which accounts for what appears to be a greater dip according to the distance than on other parts of the line. The green oil rock is found under the Pleasantville district in its proper horizon as is shown by some of the well records, but is unproductive. Between the National and Shamburg both rocks yield oil in some wells. To make the whole series of ocean elevations above given uniform—that is, all referring to the top of the 3d Sand—the elevation at the National should be about 734 feet, and at Ennis' about 762 feet.

Without doubt, the general reader will be much confused in attempting to trace the oil sands in their proper order through the mass of records here given. No effort has been made to harmonize the apparent discrepancies made by drillers in numbering the Sandrocks. The records have been copied from the originals just as they were received, only making them to conform to the general plan adopted in the publication of the whole mass of records, good, bad and indifferent, which we have on hand. It will be a work for future study to select those which are reliable and to arrange and classify them in an intelligible manner. We hope that the publication of these records as they are given to us by men who claim to understand the order and arrangement of the oil rocks, will satisfy them that they are not working understandingly, and show them the necessity of a closer examination of the measures drilled through and a more careful numbering and measurement of the Sandrocks.

Mr. Nettleton's levels, as mentioned in his report, were all based on his Ennis Hill datum. In 1874 we established the height of this Hill, by levels connecting with the railways at Tidioute, Tionesta and Rouseville, as 1713 feet above tide.* We now add 7 feet to reduce this to ocean level,† making it 1720 feet above the ocean. The elevations of the following wells have all been adjusted to this standard.

All the wells not otherwise noted are located in Venango County.

Some of the records here given from Enterprise and the Columbia farm on Oil Creek have been published in a previous issue. It will be noted that these differ from the former quite materially—a circumstance which shows how unreliable, for close study, the best of records are, even when obtained from the well owners and superintendents themselves.

To make sure always that the well record sent in should be the particular one required Mr. Nettleton adopted the plan of numbering the wells in his field book as he leveled to them. He also carried with him a paint-pot and brush and marked the same number used in his note book plainly on the samson-post. This is the "engineer's number" referred to in the blanks. When the well owner returned the record he gave, in addition to the name of the well, the number on the samson-post, and thus there could be no mistake made in adjusting the levels to the record. These numbers are given in the following pages at the end of the name of the well, in brackets, thus: Ennis Well (1), Harmonial Well No. 1 (53), &c., &c.

* At Schuylkill bridge, Philadelphia, Pennsylvania Railroad datum.
† In Raritan Bay, Coast Survey datum.

I. *Wells in the Borough of Pleasantville and adjoining its east line.*

1. *Ennis Well.* (1)

October 14, 1868.

On lease No. 3, Guild & Wright tract, adjoining east line of Borough of Pleasantville. Authority, J. L. Ennis.

Well mouth above ocean (high tide) in feet				1720
?	446	to 446	=	1274
1st S. S	56	" 502	=	1218
?	168	" 670	=	1050
2d S. S	40	" 710	=	1010
?	99	" 809	=	911
3d S. S	30	" 839	=	881
?	74	" 913	=	807
4th S. S	22	" 935	=	785

Wet hole. Cased at 446′. Pumped 4 feet from the bottom.

Best production 200 barrels per day. Gas sufficient to fire 6 boilers. Black oil; gravity 43°.

2. *Swan and Belch Well, No.* 1. (57)

January 26, 1869.

S. M. Dunham Farm, lease No. 5. Canfield tract, adjoining east line of Borough of Pleasantville. Authority, Edwin Swan.

Well mouth above ocean in feet				1678
?	180	to 180	=	1498
1st S. S	15	" 195	=	1483
?	422	" 617	=	1061
2d S. S	24	" 641	=	1037
?	79	" 720	=	958
Stray S. S	25	" 745	=	933
?	15	" 760	=	918
3d S. S	28	" 788	=	890
?	72	" 860	=	818
4th S. S. pebble and sand.	9	" 869	=	809
? pocket.	$23\frac{1}{2}$	" $892\frac{1}{2}$	=	$785\frac{1}{2}$

Wet hole. Cased at 407′. Pumped 12 feet from bottom.

Best production 130 barrels per day. Gas sufficient to fire three boilers. Black oil. Mud veins at 775′ and 862′.

3. *Bonta and Hawes Well, No.* 5. (60)

December, 1868.

Lease No. 4, Geroe farm, adjoining east line of Borough of Pleasantville. Authority, Charles P. Byron.

Well mouth above ocean in feet	1648

?		215	to 215	= 1433
1st S. S.		12	" 227	= 1421
?		205	" 432	= 1216
2d S. S.		22	" 454	= 1194
?		203	" 657	= 991
3d S. S.		50	" 707	= 941
?		135	" 842	= 806
4th S. S.	pebble.	16	" 858	= 790
?	pocket.	2	" 860	= 788

Wet hole. Cased at 280′. Pumped $1\frac{3}{4}$ feet from bottom.

Best production 120 barrels per day. Gas sufficient to fire 3 boilers. Black oil. Mud veins at 666′ and 852.′

4. *McGrew and Ritchie Well.* (5)

February 1869.

Jack Farm, McGrew, Ritchie & Co.'s tract, adjoining north-east corner of Borough of Pleasantville. Authority, James B. McClune.

Well mouth above ocean in feet				1684
?		135	to 135	= 1549
1st S. S.		85	" 220	= 1464
?		197	" 417	= 1267
2d S. S.		18	" 435	= 1249
?		194	" 629	= 1055
3d S. S.		24	" 653	= 1031
?		122	" 775	= 909
4th S. S.		35	" 810	= 874
?		67	" 877	= 807
5th S. S.	pebble.	11	" 888	= 796
?	pocket.	8	" 896	= 788

Wet hole. Cased at 425′.

Black oil.

5. *Jack Well.* (7)

February, 1869.

Jack Farm, adjoining the north-east corner of Borough of Pleasantville. Authority, George H. Jack.

Well mouth above ocean in feet				1680
?		402	to 402	= 1278
1st S. S.		18	" 420	= 1260
?		230	" 650	= 1030
2d S. S.		10	" 660	= 1020
?		65	" 725	= 955
3d S. S.		30	" 755	= 925
?		116	" 871	= 809

4th S. S.		11	"	882	= 798
?	pocket.	7	"	889	= 791

Wet hole. Cased at 405′.

Best production 12 barrels per day. Gas sufficient to fire one boiler.

6. *Rising Sun Well.* (8)

February, 1869.

Jack Farm, adjoining north-east corner of Borough of Pleasantville. Authority, Wm. A. Barnes.

Well mouth above ocean in feet					1676
?		390	to	390	= 1286
1st S. S.		28	"	418	= 1258
?		215	"	633	= 1043
2d S. S.		20	"	653	= 1023
?		112	"	765	= 911
3d S. S.		33	"	798	= 878
?		73	"	871	= 805
4th S. S.		11	"	882	= 794
?	pocket.	5	"	887	= 789

Wet hole. Cased at 397′. Black oil.

Best production per day 10 barrels. Gas sufficient to fire one boiler.

7. *Howe Well.* (11)

March, 1869.

Jack Farm, adjoining north-east corner of Borough of Pleasantville. Authority ———.

Well mouth above ocean in feet					1671
?		400	to	400	= 1271
2d S. S.		30	"	430	= 1241
? including 3d S. S.		432	"	862	= 809
4th S. S.		18	"	880	= 791
?	pocket.	6	"	886	= 785

Wet hole. Cased at 415′.

Best production 20 barrels per day. Gas sufficient to fire one boiler.

8. *Nettleton Well, No.* 1. (20)

January 17, 1866.

Nettleton tract, formerly Watkin's farm, lease No. 2, north-east corner of Borough of Pleasantville. Authority, E. S. Nettleton.

Well mouth above ocean in feet					1582
?		109	to	109	= 1473
1st S. S.		121	"	230	= 1352
?		72	"	302	= 1280
2d S. S.		46	"	348	= 1234

?		137	" 485	= 1097
Red Rock .. [redacted]		55	" 540	= 1042
3d S. S.		17	" 557	= 1025
?		170	" 727	= 855
4th S. S.		9	" 736	= 846
?		126	" 862	= 720
5th S. S.	pebble and sand.	18	" 880	= 702
?	pocket.	11½	" 891½	= 690½

Wet hole. Cased at 180′. Pumped at 22′ from bottom.

Best production 35 barrels per day. Gas sufficient to fire 4 boilers. Black oil. Gravity 44. Mud veins at 557′ and 730′. The lowest water course is at 162′. At 716′ a quartz vein was struck. Well was tested thoroughly at 736′ and 560′. At the 736′ test considerable gas was found.

9. *Richey Well, No.* 1. (15)

December, 1868.

Nettleton Farm, lease 15, Borough of Pleasantville. Authority, John Nichols.

Well mouth above ocean level.....1651

?		8	to 8	= 1643
1st S. S.		43	" 51	= 1600
?		330	" 381	= 1270
2d S. S.		34	" 415	= 1236
?		285	" 700	= 951
3d S. S.		32	" 732	= 919
?		113	" 845	= 806
4th S. S.	pebble and sand.	17	" 862	= 789

Wet hole. Cased at 384′. Pumped 5 feet from the bottom.

Best production per day 35 barrels. Gas sufficient to fire 2 boilers. Dark green oil. Gravity 43° to 48°.

10. *Plumer Well, No.* 1. (16)

April, 1869.

Nettleton Farm, Borough of Pleasantville. Authority, ———.

Well mouth above ocean in feet.....1639

?		828	to 828	= 811
4th S. S.		20	" 848	= 791
?	pocket.	2	" 850	= 789

11. *Lippincott Well, No.* 1. (18)

February, 1869

Watkin's Farm, lease 17, Borough of Pleasantville, 50 rods south of Nettleton's Well. Authority ———.

Well mouth above ocean in feet..... 1619

?	340	to	340	= 1279
2d S. S.	8	"	348	= 1271
?	232	"	580	= 1039
3d S. S.	35	"	615	= 1004
?	25	"	640	= 979
4th S. S.	25	"	665	= 954
?	30	"	695	= 924
5th S. S.	20	"	715	= 904
?	99	"	814	= 805
6th S. S.	18	"	832	= 787
?.....pocket.	8	"	840	= 779

Wet hole. Cased at 341′.

Best production 3 barrels per day. Gas sufficient to fire two boilers. Black oil. Mud vein at 700′.

12. *Blakesley Well.* (14)

November, 1868.

Brown and House Farm, situated in the Borough of Pleasantville. Authority ———.

Well mouth above ocean in feet				1672
?	400	to	400	= 1272
2d S. S. estimated	25	"	425	= 1247
?	200	"	625	= 1047
3d S. S. estimated	15	"	640	= 1032
?	70	"	710	= 962
Stray S. S.	15	"	725	= 947
?	40	"	765	= 907
4th S. S.	40	"	805	= 867
?	56	"	861	= 811
5th S. S.	19	"	880	= 792

Wet hole. Cased at 415′.

Best production 10 barrels per day. Gas sufficient to fire one boiler. Black oil.

13. *United States Petroleum Co.'s Well, No.* 27. (23)

October 9, 1868.

Brown and House Tract, Borough of Pleasantville. Authority Wm. H. Kerns.

Well mouth above ocean in feet				1676
?	392	to	392	= 1284
1st S. S.	23	"	415	= 1261
?	206	"	621	= 1055
2d S. S.	40	"	661	= 1015
?	112	"	773	= 903
3d S. S.	25	"	798	= 878

?.....		74	" 872	= 804
4th S. S.....Sand.....		15	" 887	= 789
?.....	pocket.	7	" 894	= 782

Wet hole. Cased at 631′.

Best production 60 barrels per day. Gas sufficient to fire three boilers. Black oil.

14. *Harsh Well, No.* 3. (28)

October 20th, 1868.

Harsh tract, lease No. 3. Borough of Pleasantville. Authority, Samuel Harsh.

Well mouth above ocean in feet.....				1682
?.....		30	to 30	= 1652
1st S. S.....		40	" 70	= 1612
?.....		66	" 136	= 1546
2d S. S. estimated.....		20	" 156	= 1526
?.....		609	" 765	= 917
3d S. S. estimated.....		30	" 795	= 887
?.....		77	" 872	= 810
4th S. S.....	pebble and sand.	15	" 887	= 795
?.....	pocket.	7½	" 894½	= 787½

Wet hole. Cased at 450′. Pumped 9′ from bottom.

Best Production 70 barrels per day. Gas sufficient to fire 2½ boilers. Black oil.

Struck a water course at 140′ from the surface. A dry crevice, struck at 250′ from the surface, carried off the water coming in at 140′.

15. *Shriver Well, No.* 1. (29)

October 28th, 1868.

Harsh tract, lease No. 1, Borough of Pleasantville. Authority, Albert Insinger, Jr.

Well mouth above ocean in feet.....				1674
?.....		20	to 20	= 1654
1st S. S.....		45	" 65	= 1609
?.....		545	" 610	= 1064
2d S. S.....		32	" 642	= 1032
?.....		103	" 745	= 929
3d S. S.....		30	" 775	= 899
?.....		97	" 872	= 802
4th S. S.....4 feet at top pebble; bottom sand.		20	" 892	= 782
?.....	pocket.	1	" 893	= 781

Wet hole. Cased at 615′. Pumped 3 feet from the bottom.

Best production 30 barrels per day. Gas sufficient to fire one boiler. Black oil. Mud veins at 760′ and 877′.

16. *Tidioute Well, No.* 1. (30)

October, 1868.

Connely Farm, Borough of Pleasantville. Authority, ———

Well mouth above ocean in feet				1670
?	410	to	410	= 1260
1st S. S	30	"	440	= 1230
?	193	"	633	= 1037
2d S. S	20	"	653	= 1017
?	102	"	755	= 915
3d S. S	30	"	785	= 885
?	82	"	867	= 803
4th S. S	17	"	884	= 786

Wet hole. Cased at 428′.

Best production 135 barrel per day. Gas sufficient to fire 2 boilers.

17. *Crocker Well.* (31)

October, 1869.

Connely tract, Borough of Pleasantville, Authority, ———.

Well mouth above ocean in feet				1675
?	408	to	408	= 1267
1st S. S	18	"	426	= 1249
?	440	"	866	= 809
4th S. S	20	"	886	= 789

Wet hole. Cased at 412′.

Best production 26 barrels per day. Gas sufficient to fire 1½ boilers. Black oil.

18. *Beam Well, No.* 1. (37)

June 25, 1868.

On land bought of T. B. Shugart, M.D., in Borough of Pleasantville. Authority, Beam Bros.

Well mouth above ocean in feet				1646
?	100	to	100	= 1546
1st S. S	12	"	112	= 1534
?	258	"	370	= 1276
2d S. S	15	"	385	= 1261
?	212	"	597	= 1049
3d S. S	28	"	625	= 1021
?	111	"	736	= 910
4th S. S	35	"	771	= 875
?	69	"	840	= 806
5th S. S.....yellow; pebble at top and middle.	17	"	857	= 789
?.....pocket.	1	"	858	= 788

Wet hole. Cased at 609. Pumped 3½ feet from bottom.

Best production 68 barrels per day. Gas sufficient to fire 18 boilers. Black oil. Mud veins at 746′ and 848′.

The sand rocks were all measured when struck and when through, with the exception of the 1st or Mt. sand, which was calculated by the length of the tools standing in the derrick and by the rope to the wrapper. Average production to January, 1869—6 months and 5 days—30 barrels per day. Tubing drawn only twice, and only four days stoppage altogether during that period. Production at January 1, 1869, 7 barrels per day.

19. *Say Well, No.* 6. (42)

November 26, 1868,

Zuver Farm, Borough of Pleasantville. Authority, Williams, Say & Co.

Well mouth above ocean in feet				1632
?	207	to	207	= 1425
1st S. S	92	"	299	= 1333
?	141	"	440	= 1192
2d S. S	20	"	460	= 1172
?	225	"	685	= 947
3d S. S	22	"	707	= 925
?	106	"	813	= 819
4th S. S	40	"	853	= 779
?	65	"	918	= 714
5th S. S. pebble.	18	"	936	= 696

Wet hole. Cased at 362′. Pumped 6 feet from bottom.

Best production 15 barrels per day. Gas sufficient to fire 2 boilers. Black oil.

20. *Say Well, No.* 5. (43)

September 29, 1868.

Zuver Farm, lease No. 1, Borough of Pleasantville. Authority, Williams, Say & Co.

Well mouth above ocean in feet				1623
?	110	to	110	= 1513
1st S. S	92	"	202	= 1421
?	141	"	343	= 1280
2d S. S	20	"	363	= 1260
?	225	"	588	= 1035
3d S. S	22	"	610	= 1013
?	114	"	724	= 899
4th S. S	60	"	784	= 839
?	36	"	820	= 803
5th S. S. pebble.	14	"	834	= 789

Wet hole. Cased at 356′. Pumped 5 feet from bottom.

Best production 90 barrels per day. Gas sufficient to fire 4 boilers. Black oil. Gravity 49°.

Too many holes drilled in the immediate vicinity for the good health of this well.

21. *Say Well, No. 2.* (54)

June 15, 1868.

Zuver Farm, lease No. 2, Borough of Pleasantville. Authority, Williams, Say & Co.

Well mouth above ocean in feet				1618
?	100	to	100	= 1518
1st S. S	90	"	190	= 1428
?	147	"	337	= 1281
2d S. S	20	"	357	= 1261
?	223	"	580	= 1038
3d S. S	25	"	605	= 1013
?	115	"	720	= 898
4th S. S	60	"	780	= 838
?	38	"	818	= 800
5th S. S	17	"	835	= 783

Wet Hole. Cased at 355′. Pumped 3′ from bottom.

Best production 80 barrels per day. Gas sufficient to fire 15 boilers. Black oil.

22. *Benedict Well.* (280)

February, 1869.

On Joseph Benedict's Lot, Borough of Pleasantville. Authority, C. L. Raver & Co.

Well mouth above ocean in feet				1634
?	390	to	390	= 1244
1st S. S	15	"	405	= 1229
?	197	"	602	= 1032
2d S. S	25	"	627	= 1007
?	103	"	730	= 904
3d S. S	40	"	770	= 864
?	62	"	832	= 802
4th S. S	18	"	850	= 784
?.....pocket.	5	"	855	= 779

Wet hole. Cased at 390′. Gas sufficient to fire one boiler.

Best production 3 barrels per day.

23. *Porter and Taylor Well, No.* 1. (49)

November 17, 1868.

Wm. Porter Farm, Borough of Pleasantville. Authority, Stephen Hine.

Well mouth above ocean in feet				1617
?	350	to	350	= 1267
1st S. S.	25	"	375	= 1242
?	210	"	585	= 1032
2d S. S.	40	"	625	= 992
?	90	"	715	= 902
3d S. S.	40	"	755	= 862
?	51	"	806	= 811
4th S. S. fine pebble.	19	"	825	= 792
? pocket	$4\frac{1}{2}$	"	$829\frac{1}{2}$	= $787\frac{1}{2}$

Wet hole. Cased at 355′. Pumped 6 feet from bottom.

Best production per day 14 barrels. Gas sufficient to fire one boiler. Black oil.

24. *Harmonial Well, No.* 1. (53)

February 1, 1868.

Wm. Porter Farm, Borough of Pleasantville. Authority, Norman Potter, agent.

Well mouth above ocean in feet				1614
?	70	to	70	= 1544
1st S. S.	12	"	82	= 1532
?	494	"	576	= 1038
2d S. S.	40	"	616	= 998
?	91	"	707	= 907
3d S. S.	40	"	747	= 867
?	65	"	812	= 802
4th S. S. 15′ pebble, 3′ sand.	18	"	830	= 784
Slate pocket.	5	"	835	= 779

Wet hole. Cased at 312′. Pumped 9 feet from bottom.

Best production 125 barrels per day. Gas sufficient to fire 3 to 4 boilers. Black oil. Gravity 47°. Mud veins in 2d, 3d and 4th sands.

Well was cased first at 380′; flowed 3 months, averaging 100 barrels per day, but running down, it finally ceased yielding oil in paying quantities November 1, 1868. It was then drilled deeper, showing the following record:

Thickness of measures to bottom of 4th S. S.	830	to	830	= 784
Slate	24	"	854	= 760
5th S. S.	20	"	874	= 740
? pocket	6	"	880	= 734

The 5th or "green oil sand," was fine, gray and muddy. It furnished a good supply of gas and some green oil, but not in sufficient quantity to pay the expenses of pumping the well.

25. *Comey and Andrews Well, No.* 1. (113)

November 9, 1868.

Lease No. 11, west part of Porter Farm, now Brown, Byers & Co. Borough of Pleasantville. Authority, Gaylord Mattison.

Well mouth above ocean in feet				1581
?	100	to	100	= 1481
1st S. S.	140	"	240	= 1341
?	75	"	315	= 1266
2d S. S.	25	"	340	= 1241
?	80	"	420	= 1161
3d S. S.	30	"	450	= 1131
?	230	"	680	= 901
4th S. S.	20	"	700	= 881
?	95	"	795	= 786
5th S. S. pebble.	18	"	813	= 768
? pocket.	7	"	820	= 761

Wet hole. Cased at 320′. Pumped 9′ from the bottom.

Best production 3 barrels per day. Gas sufficient to fire ½ boiler. Black oil. Gravity 45°.

26. *McGrew Well, No.* 1. (70)

1868.

Brown Brothers Farm, Borough of Pleasantville. Authority, James McGrew.

Well mouth above ocean in feet				1635
?	12	to	12	= 1623
1st S. S.	26	"	38	= 1597
?	338	"	376	= 1259
2d S. S.	12	"	388	= 1247
?	208	"	596	= 1039
3d S. S.	43	"	639	= 996
?	99	"	738	= 897
4th S. S.	27	"	765	= 870
?	70	"	835	= 800
5th S. S.	18	"	853	= 782
? pocket.	2	"	855	= 780

Wet hole. Cased at 382′. Black oil. Mud veins in 4th and 5th S. S's.

The numbers given to the sands are not the proper ones, as the mountain sand should not be counted. We pumped the well at several points in the sand marked 5th S. S. as above. I do not recall how many feet of pebble sand there were.

27. *Harmonial Well, No. 2.* (95)

July 1, 1868.

Armstrong Farm, lease No. 40, three-quarters of a mile nearly south from Pleasantville Corners. Authority, Norman Potter, agent.

Well mouth above ocean in feet				1641
?	36	to	36	= 1605
1st S. S.	60	"	96	= 1545
?	294	"	390	= 1251
2d S. S. estimated.	20	"	410	= 1231
?	350	"	760	= 881
3d S. S.	25	"	785	= 856
?	55	"	840	= 801
4th S. S. sand and pebble.	16	"	856	= 785
? pocket.	14	"	870	= 771

Wet hole. Cased at 395′. Pumped 14 feet from bottom.

Best production 80 barrels per day. Gas sufficient to fire 2 boilers. Black oil. Gravity 45°.

The three upper rocks were very much broken up. Production at this date (December 19, 1868) 10 barrels per day.

II. *Wells in the vicinity of Pleasantville.*

28. *Baldwin and Porter Well, No. 1.* (238)

February, 1869.

On Gates Farm, Nicltown Road, three-quarters of a mile north-east of the Borough of Pleasantville. Authority, James B. McClune.

Well mouth above ocean in feet				1616
?	110	to	110	= 1506
1st S. S.	90	"	200	= 1416
?	140	"	340	= 1276
2d S. S.	31	"	371	= 1245
?	203	"	574	= 1042
3d S. S.	21	"	595	= 1021
?	117	"	712	= 904
4th S. S.	36	"	748	= 868
?	70	"	818	= 798
5th S. S.	12	"	830	= 786
?	27	"	857	= 759
6th S. S. top white pebble, bottom gray sand.	20	"	877	= 739
? pocket.	10	"	887	= 729

Wet hole. Cased at 353′. Gas sufficient to fire 8 boilers.

This well was tested at 840′ in the "Black oil sand," and afterwards drilled to 887′. The flow of gas came from the lower or "Green oil sand." But little oil in either of the sands.

29. *Norman Potter Well.* (308)

January 1st. 1870.

On Aaron Gates' Farm, 1 mile north-east of Pleasantville. Authority ?

Well mouth above ocean in feet				1512
?	225	to	225	= 1287
1st S. S.	20	"	245	= 1267
?	215	"	460	= 1052
2d S. S.	28	"	488	= 1024
?	112	"	600	= 912
3d S. S	22	"	622	= 890
?.....703′ to 707′, pebbly.	109	"	731	= 781
4th S. S.....5′ pebble. 16′ gray sand.	21	"	752	= 760
?.....pocket.	7	"	759	= 753

This well at the present time is pumping about 20 barrels of salt water per day. (Jan. 4th, 1870.)

30. *Mason Well.* (277)

1865–6.

On Prosser Farm, about $1\frac{1}{2}$ miles north 80° east of Pleasantville. Authority, Jas. B. McClune.

Well mouth above ocean in feet				1551
?	90	to	90	= 1461
1st S. S.	68	"	158	= 1393
?	94	"	252	= 1299
2d S. S.	18	"	270	= 1281
?	228	"	498	= 1053
3d S. S.	13	"	511	= 1040
?	69	"	580	= 971
4th S. S.	20	"	600	= 951
?	30	"	630	= 921
5th S. S.	28	"	658	= 893
?	134	"	792	= 759
6th S. S.	10	"	802	= 749
? pocket.	3	"	805	= 746

Wet hole. Cased at 260′. Green Oil show.
Mud veins at 582′ and 634′.

31. *Fobes Well.* (278)

Fall of 1865.

Dunham Farm, $1\frac{1}{2}$ miles east of Pleasantville. Authority, George C. Fobes.

Well mouth above ocean in feet				1521
?	85	to	85	= 1436
1st S. S.	55	"	140	= 1381

?	79	to 219	=	1302
2d S. S.	34	" 253	=	1268
?	284	" 537	=	984
3d S. S.	31	" 568	=	953
?	35	" 603	=	918
4th S. S.	28	" 631	=	890
?	86	" 717	=	804
5th S. S.	2	" 719	=	802
?	15	" 734	=	787
6th S. S.	11	" 745	=	776
?	96	" 841	=	680
Sand, shales and pebbles	24	" 865	=	656
?	11	" 876	=	645
Red Rock	57	" 933	=	588
Slate	107	"1040	=	481
Red Rock	10	"1050	=	471

Wet hole. Cased at —. Mud veins at 507′ and 597′.

This well was tested at 650′, and then drilled to its present depth and tested again, with but little show of oil at either point.

32. *Steele Well, No.* 1. (120)

November, 1868.

Benj. Tyrrell Farm, 1¼ miles south-east of Pleasantville, near Ledsham Well. Authority, ———.

Well mouth above ocean in feet				1566
?	620	to 620	=	946
3d S. S.	37	" 657	=	909
?	115	" 772	=	794
5th S. S. pebble.	17	" 789	=	777
? pocket.	7	" 796	=	770

Wet hole. Cased at 318′. Pumped 24 feet from bottom.

Best production 8 barrels per day. Black oil.

33. *Ledsham Well, No.* 1. (121)

November, 1866.

S. Q. Brown and Porter (or B. Tyrrel) Farm, 1¼ mile south-east of Pleasantville. Authority, Alfred Ledsham.

Well mouth above ocean in feet				1550
?	97	to 97	=	1453
1st S. S.	18	" 115	=	1435
?	141	" 256	=	1294
2d S. S.	58	" 314	=	1236
?	170	" 484	=	1066
3d S. S.	41	" 525	=	1025

?		58	to 583	= 967
4th S. S.		73	" 656	= 894
?		74	" 730	= 820
5th S. S.	brown coarse pebble.	13	" 743	= 807
?		27	" 770	= 780
6th S. S.	pebble.	20	" 790	= 760
?	pocket.	28	" 818	= 732

Wet hole. Cased at 300′. Pumped 15′ from bottom.

Best production 16 barrels per day. Half enough gas to fire one boiler. Black oil. Gravity 44°.

The 4th S. S. consists of two layers with a small stratum of slate intervening about the middle (say 10′ of slate). The 5th S. S. is of uniform texture throughout. The 6th S. S. is white, and finer than the 5th S. S.

34. *Terry Well.* (125)

———— ———— ————.

Bean Farm, $2\frac{3}{4}$ miles south-east of Pleasantville, near Farmers' Hotel. Authority, ————.

Well mouth above ocean in feet				1487
?		203	to 203	= 1284
1st S. S.		28	" 231	= 1256
?		196	" 427	= 1060
2d S. S.		26	" 453	= 1034
?		72	" 525	= 962
3d S. S.		20	" 545	= 942
?		25	" 570	= 917
4th S. S.		18	" 588	= 899
?		90	" 678	= 809
5th S. S.		14	" 692	= 795
?	pocket.	1	" 693	= 794

Wet hole. Black oil.

Wells have been put down deeper in the vicinity of this well which find 27′ of slate between the two lower sands, the 5th and 6th.

35. *Golden Well, No.* 2. (165)

February, 1868.

Pithole Golden and Cherry Run Petroleum Company's Golden Farm, 2 miles south of Pleasantville. Authority, John F. Carll.

Well mouth above ocean in feet				1551
?		72	to 72	= 1479
1st S. S.		75	" 147	= 1404
?		151	" 298	= 1253
2d S. S.		17	" 315	= 1236
?		131	" 446	= 1105

3d S. S.	11	to	457	= 1094
?	79	"	536	= 1015
4th S. S.	19	"	555	= 996
?	61	"	616	= 935
5th S. S.	21	"	637	= 914
?	32	"	669	= 882
6th S. S.	21	"	690	= 861
?	79	"	769	= 782
7th S. S. ....pebble and sand.	15	"	784	= 767
? ....pocket.	1	"	785	= 766

Wet hole. Cased at 300′. Pumped 2′ from bottom.

Best production 7 barrels per day. Half enough gas to fire a boiler. Black oil. Gravity 47°. Mud veins at 678′ and 777′.

36. *North Star Well, No. 2.* (163)

January 9, 1869.

Lease No. 1, North Star Company's "Clark Farm," 1½ miles south of Pleasantville. Authority, T. Chattle.

Well mouth above ocean in feet				1611
?	153	to	153	= 1458
1st S. S.	20	"	173	= 1438
?	172	"	345	= 1266
2d S. S.	25	"	370	= 1241
?	260	"	630	= 981
3d S. S.	62	"	692	= 919
?	23	"	715	= 896
4th S. S.	35	"	750	= 861
?	65	"	815	= 796
5th S. S.	12	"	827	= 784

Wet hole. Cased at 347′. Pumped 3′ 6″ from bottom.

Best production 35 barrels per day. Gas sufficient to fire one boiler. Dark oil. Mud veins 740′ and 822′.

37. *Hoozier Well.* (287)

1865.

At Dawson Centre, Pithole Creek, 1½ miles above Pithole City, and 4 miles south of Pleasantville. Authority, Norman R. Bates.

Well mouth above ocean in feet				1357
?	124	to	124	= 1233
1st S. S.	24	"	148	= 1209
?	209	"	357	= 1000
2d S. S.	24	"	381	= 976
?	76	"	457	= 900
3d S. S.	30	"	487	= 870

?		103	to	590	= 767
4th S. S.		20	"	610	= 747
?	pocket.	33	"	643	= 714

Best production 15 barrels per day. Green oil.

38. *Skidmore Well.* (293)

April, 1869.

McBride Farm, "Tip Top," 2½ miles south of Pleasantville. Authority?

Well mouth above ocean in feet..... 1623

?		787	to	787	= 835
4th S. S.		25	"	812	= 810
?		63	"	875	= 747
5th S. S.		22	"	897	= 725
?	pocket.	3	"	900	= 722

Wet hole. Cased at 420′.

Best production 35 barrels per day. Half enough gas to fire a boiler. Black oil.

This well is supposed to be pumping from the same as the 4th rock in Pleasantville, but the oil is of lighter color.

39. *Black Well.* (292)

——— ———.

Lease No. 25, Winslow Petroleum Co., "Tip Top," 2½ miles south of Pleasantville. Authority, Mr. Loud, Superintendent.

Well mouth above ocean in feet..... 1530

?		118	to	118	= 1412
1st S. S.		65	"	183	= 1347
?		123	"	306	= 1224
2d S. S.		34	"	340	= 1190
?		200	"	540	= 990
3d S. S.		16	"	556	= 974
?		14	"	570	= 960
4th S. S.		26	"	596	= 934
?		37	"	633	= 897
5th S. S.		22	"	655	= 875
?		43	"	698	= 832
6th S. S.		25	"	723	= 807
?		67	"	790	= 740
7th S. S.	pebble.	5	"	795	= 735
?		3	"	798	= 732
8th S. S.	pebble.	6	"	804	= 726
?	pocket.	10	"	814	= 716

Wet hole.

Best production 1 barrel per day. Half enough gas to fire a boiler.

40. *Olive Well.* (182)

1865.

Herbert Tract, Mill Farm, $2\frac{1}{4}$ miles south of Pleasantville. Authority?

Well mouth above ocean in feet					1486
?		202	to	202	= 1284
1st S. S.		38	"	240	= 1246
?		130	"	370	= 1116
2d S. S.		5	"	375	= 1111
?		155	"	530	= 956
3d S. S.		10	"	540	= 946
?		97	"	637	= 849
4th S. S.		21	"	658	= 828
?		77	"	735	= 751
5th S. S.		15	"	750	= 736
?		10	"	760	= 726
6th S. S.	pebble and sand.	12	"	772	= 714
?	pocket.	29	"	811	= 685

Wet hole. Not cased. Seed bag at 480′.
Black oil. Gravity 45°.

41. *Buffalo Well, No.* 1. (181)

December 26th, 1868.

Lease A, (10 acres,) Mill Farm, $1\frac{3}{4}$ miles south of Pleasantville. Authority, Wm. Williams & S. Simpkins.

Well mouth above ocean in feet					1486
?		60	to	60	= 1426
1st S. S.		50	"	110	= 1376
?		150	"	260	= 1226
2d S. S.		25	"	285	= 1201
?		240	"	525	= 961
3d S. S.		15	"	540	= 946
?		50	"	590	= 896
4th S. S.		20	"	610	= 876
?		130	"	740	= 746
5th S. S.	pebble and sand.	16	"	756	= 730

Wet hole. Cased at 535′. Pumped 7′ from bottom.
Best production 4 barrels per day. Half enough gas to fire 1 boiler.
Black oil. Gravity 47°.
This well is supposed to be flooded by several old abandoned wells in the immediate vicinity. Have pumped in 27 days 42 barrels of roily oil, green and black, principally black.

42. *Snyder Well, No.* 1. (180)

December, 1868.

Lease No. 3, Mill farm, $1\frac{3}{4}$ miles south of Pleasantville. Authority, J. C. Champion.

Well mouth above ocean in feet				1510
?	50	to	50	= 1460
1st S. S.	40	"	90	= 1420
?	165	"	255	= 1255
2d S. S.	25	"	280	= 1230
?	130	"	410	= 1100
3d S. S.	25	"	435	= 1075
?	70	"	505	= 1005
4th S. S.	20	"	525	= 985
?	70	"	595	= 915
5th S. S.	14	"	609	= 901
?	31	"	640	= 870
6th S. S.	20	"	660	= 850
?	80	"	740	= 770
7th S. S.	18	"	758	= 752
?.....pocket.	2	"	760	= 750

Wet hole. Cased at 275′. Pumped 8′ from bottom.

Best production 90 barrels per day. Gas sufficient to fire 1 boiler. Black oil. Gravity 48°. Mud veins in both the lower sands.

43. *Bates Well, No.* 1. (102)

—— —— 1866

Dawson Farm, $1\frac{1}{3}$ miles south of Pleasantville. Authority, N. R. Bates.

Well mouth above ocean in feet				1587
?	560	to	560	= 1027
3d S. S. estimated	30	"	590	= 997
?	50	"	640	= 947
4th S. S.	30	"	670	= 917
?	122	"	792	= 795
5th S. S.....fine pebble and sand.	13	"	805	= 782
?.....pocket.	15	"	820	= 767

Wet hole. Cased at 400′. Pumped 20′ from bottom.

Black oil. Gravity 47°, when first pumped.

At one time during the first ninety days of the production the well yielded at the rate of 500 barrels per day, and was running at this rate when the men, in the excitement occasioned by so great a flow of oil, "shut down" to connect with a larger tank. This seemed to check the flow so effectually that the well could never again be brought up to its former production. The first part of the record was lost. My driller re-

ported *lime* and sand for 30′ above the 5th S. S. Overlying this was a stratum of *soapstone* more than 20′ thick, in which was a *crevice* or cavity 5′ in depth, then 3′ of soapstone, then a *cavity* of 11′ in depth, as measured by pole tools.*

44. *Bates Petroleum Co. Well, No. 3.* (119)

Fall and Winter of 186[illegible].

Matteson Farm, Pleasantville and Enterprise road, half a mile north of Pleasantville. Authority, N. R. Bates.

Well mouth above ocean in feet				1463
?	175	to	175	= 1288
1st S. S.	40	"	215	= 1248
?	201	"	416	= 1047
2d S. S.	40	"	456	= 1007
?	105	"	561	= 902
3d S. S.	33	"	594	= 869
?	84	"	678	= 785
4th S. S. inferior, gray.	12	"	690	= 773
?	10	"	700	= 763
5th S. S. close, some pebbles.	20	"	720	= 743
? pocket.	10	"	730	= 733

Wet hole. Cased at 190.

Best production half barrel per day. Gas sufficient to fire half boiler. Green oil.

When this well was first tested, after a few days of pumping, it showed very well, giving considerable gas and throwing at intervals a full pipe of oil. At this time an accident occurred, fastening the working valve so as to necessitate the drawing of the tubing. As the well was not cased at this time it seemed to be injured very much by the letting in of the water, and never again made so good a show as at first.

45. *Paschmacker Well.* (198)

1868.

Near school house on Pleasantville and Enterprise road, 1 mile north of Pleasantville. Authority, M. P. Barber.

Well mouth above ocean in feet				1586
?	306	to	306	= 1280
1st S. S.	21	"	327	= 1259
?	53	"	380	= 1206
2d S. S.	26	"	406	= 1180

* As these well records are here merely placed on record no comment is made on such extraordinary (or rather, ordinary) statements. The literature of oil is full of them. They are mostly based on errors of observation easily explained. [J. P. L.]

?	284	to 690	=	896
3d S. S.	20	" 710	=	876
?	110	" 820	=	766
4th S. S.	21	" 841	=	745
?.....pocket.	114	" 955	=	631

Wet hole.

Best production —. Green oil. Little gas. Red water.

46. *Eaton Well.* (289)

April, 1869.

On lease No. 1, J. Y. Siggins Farm, 1 mile north-west of Pleasantville. Authority, James Y. Siggins.

Well mouth above ocean in feet				1668
?	140	to 140	=	1528
1st S. S.	35	" 175	=	1493
?	45	" 220	=	1448
2d S. S.	50	" 270	=	1398
?	373	" 643	=	1025
3d S. S.	40	" 683	=	985
?	97	" 780	=	888
4th S. S.....pebble.	20	" 800	=	868
?	121	" 921	=	747
5th S. S.....sand	12	" 933	=	735
?.....pocket.	9	" 942	=	726

Wet hole. Cased at 450′. Mud veins at centre of 3d and 4th sands.

Best production 2 gallons per day. Green oil.

About 10′ of the top of the 4th S. S. was pebbly and ought to have produced oil, if immediately tested, but the well was drilled to the 5th sand before the tubing was put in. This sand was white and close, with no pebbles.

47. *Siggins Well.* (291)

November, 1868.

James Y. Siggins Farm, 1 mile north-west of Pleasantville. Authority, James Y. Siggins.

Well mouth above ocean in feet				1535
?	95	to 95	=	1440
1st S. S.	40	" 135	=	1400
?	125	" 260	=	1275
2d S. S.	37	" 297	=	1238
?	219	" 516	=	1019
3d S. S.	42	" 558	=	977
?	103	" 661	=	874

4th S. S.	15	to 676	=	859
?	104	" 780	=	755
5th S. S.	19	" 799	=	736
?	81	" 880	=	655

Wet hole.

The 4th S. S. was a splendid pebble rock with excellent show of oil. Got the sand pump stuck in drilling and had to drill it out, and this is thought to have spoiled the well.

48. *Smythe Well.* (118)

1869.

John McCaslin Farm, 1 mile west of Pleasantville. Authority, ———.

Well mouth above ocean in feet				1608
?	142	to 142	=	1466
1st S. S.	66	" 208	=	1400
?	128	" 336	=	1272
2d S. S.	36	" 372	=	1236
?	208	" 580	=	1028
3d S. S.	42	" 622	=	986
?	98	" 720	=	888
4th S. S.	29	" 749	=	859
?	110	" 859	=	749
5th S. S. gray sand.	19	" 878	=	730
? pocket.	5	" 883	=	725

Wet hole. Cased at 375′.

No paying production. The well was tested at 749′, where some black oil was obtained. Afterwards the well was put down to the next (5th) S. S., from which it produced very little green oil.

49. *Horseshoe Well, No.* 1. (117)

July, 1866.

On Pithole, Golden and Cherry Run Oil Co.'s tract, $1\frac{1}{4}$ miles south-west of Pleasantville. Authority, John F. Carll.

Well mouth above ocean in feet				1553
?	135	to 135	=	1418
1st S. S.	30	" 165	=	1388
?	120	" 285	=	1268
2d S. S.	35	" 320	=	1233
?	220	" 540	=	1013
3d S. S.	28	" 568	=	985
?	106	" 674	=	879
4th S. S.	27	" 701	=	852

?.....		104	"	805	= 748
5th S. S.....sand and pebble.		35	"	840	= 713

Wet hole. Cased at 300′. Pumped 10′ from bottom.

Best production a few gallons per day. Green oil. Gas sufficient to fire 2 boilers.

Mud veins at 540′, 695′, and 765′.

50. *Children's Well, No.* 1. (97)

November 4, 1868.

Armstrong Farm, lease 101, adjoining Brown Bros. tract, ½ mile south of the Borough of Pleasantville. Authority, ———.

Well mouth above ocean in feet					1638
?		834	to	834	= 804
4th S. S.....pebble and sand.		12	"	846	= 792
?.....pocket.		14	"	860	= 778

Wet hole. Cased at 418′.

Best production 42 barrels per day. Gas sufficient to fire 3 boilers. Black Oil.

51. *Brown and Warner Well.* (110)

March, 1868.

Armstrong Farm, lease No. 89, ½ mile south of Pleasantville. Authority?

Well mouth above ocean in feet....					1579
?		328	to	328	= 1251
1st S. S.....		30	"	358	= 1221
?		427	"	785	= 794
4th S. S.....		18	"	803	= 776

Wet hole. Cased at 340′. Black Oil.

Best production 90 barrels per day.

52. *Maple Shade Well, No.* 1. (105)

July 7th, 1868.

Brown, Fertig and Hammond tract, 1¼ miles south of Pleasantville. Authority, ———.

Well mouth above ocean in feet.....					1555
?.....		768	to	768	= 787
4th S. S.....		18	"	786	= 769
?.....pocket.		6	"	792	= 763

Wet hole. Cased at 418′.

Best production 150 barrels per day. Gas sufficient to fire 4 boilers. Black Oil.

This record is unreliable.

53. *Holbrook Well, No.* 1. (81)

August, 1866.

New York and Providence Petroleum Co. farm, 1 mile south-west of Pleasantville Corners. Authority, R. W. Holbrook.

Well mouth above ocean in feet					1540
?		104	to	104	= 1436
1st S. S.		47	"	151	= 1389
?		147	"	298	= 1242
2d S. S.		20	"	318	= 1222
?		205	"	523	= 1017
3d S. S.		27	"	550	= 990
?		110	"	660	= 880
4th S. S.		22	"	682	= 858
?		74	"	756	= 784
5th S. S.	pebble.	24	"	780	= 760
?		15	"	795	= 745
6th S. S.		30	"	825	= 715
?	pocket.	15	"	840	= 700

Wet hole. Cased at 325′. Pumped 72 feet from bottom.

Best production 15 barrels per day. Gas sufficient to fire 2 boilers. Black oil. Gravity 42°.

The 6th sandrock was found to be a hard close white sand. The well has been tubed from 756 feet to 816 feet, with same result. Good show of oil and gas in the 4th S. S.

54 *Concordia Well.* (174)

1868

North-east part of James Farrel Farm, lease No. 1, $1\frac{3}{4}$ miles south-west of Pleasantville. Authority, ———.

Well mouth above ocean in feet					1578
?	pocket.	100	to	100	= 1478
1st S. S.		80	"	180	= 1398
?		180	"	360	= 1218
2d S. S.		28	"	388	= 1190
?		212	"	600	= 978
3d S. S.		18	"	618	= 960
?		192	"	810	= 768
4th S. S.		27	"	837	= 741
?		10	"	847	= 731
5th S. S.	sand.	40	"	887	= 691

Wet hole. Cased at 350′.

Best production a "good show" of green oil. Mud vein at 815′.

55. *Baum Well, No.* 1. (175)

1868.

South-east part of north half of J. Farrell Farm, 1½ miles south-west of Pleasantville. Authority, Grant Parkhurst.

Well mouth above ocean in feet					1573
?	90	to	90	=	1483
1st S. S.	100	"	190	=	1383
?	154	"	344	=	1229
2d S. S.	20	"	364	=	1209
?	216	"	580	=	993
3d S. S.	21	"	601	=	972
?	179	"	780	=	793
4th S. S.	18	"	798	=	775
?	36	"	834	=	739
5th S. S.	38	"	872	=	701
?.....pocket.	15	"	887	=	686

Wet hole. Cased at 360′.

Best production 3 barrels per day. Half enough gas to fire one boiler. Black oil in 4th S. S., and green oil in 5th S. S. Gravity, black oil 48°, and green oil 46°.

The above well was drilled in the winter of 1867 8; was tested at 810′ and failed to produce oil in paying quantities; was then drilled to the depth of 878′ with the same result. Yellow pebble at 800′, white pebble at 835′. The well has since been abandoned. I do not think it was ever properly tested at 844′ or in the 5th S. S.

56. *Phœnix Well, No.* 1. (86)

August, 1868.

Bates Petroleum Co. tract, 1½ miles south-west of Borough of Pleasantville. Authority, ———.

Well mouth above ocean in feet					1520
?	80	to	80	=	1440
1st S. S.	56	"	136	=	1384
?	131	"	267	=	1253
2d S. S.	20	"	287	=	1233
?	218	"	505	=	1015
3d S. S.	15	"	520	=	1000
?	120	"	640	=	880
4th S. S.	25	"	665	=	855
?	74	"	739	=	781
5th S. S.....pebble and sand	36?	"	775	=	745

Wet hole. Cased at 510′.

Best production 90 barrels per day. Gas sufficient to fire 2 boilers. Black oil.

[The record of this well, as given in the blank, from the top of the 5th S. S. down is evidently wrong. It is as follows:

Top of 5th S. S.	739′
Thickness	28′
Top of 6th S. S.	761′
Thickness	14′
Depth of well	775′]

57. *National Well, No. 2.* (87)

National Oil Co. tract, 1½ miles south-west of Borough of Pleasantville. Authority, E. L. Pitcher.

Well mouth above ocean in feet				1526
?		101 to 101	=	1425
1st S. S.		29 " 130	=	1396
?		150 " 280	=	1246
2d S. S.		32 " 312	=	1214
?		226 " 538	=	988
3d S. S.		21 " 559	=	967
?		41 " 600	=	926
4th S. S.		69 " 669	=	857
?		78 " 747	=	779
5th S. S.	pebble.	15 " 762	=	764
?	pocket.	7 " 769	=	757

Wet hole. Cased at 300′. Pumped 7 feet from bottom.

Best production 83 barrels per day. Gas sufficient to fire 1½ boilers. Black oil. Gravity 49°. The 4th S. S. is broken by 20 feet of slate and shelly rock.

III. *Wells at Shamburg and Vicinity.*

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58. *Pierson Well.* (177)

1869.

King lot, three-quarters of a mile north-east of Shamburg. Authority, William Morgan.

Well mouth above ocean in feet				1584
?		149 to 149	=	1435
1st S. S.		60 " 209	=	1375
?		147 " 356	=	1228
2d S. S.		23 " 379	=	1205
?		241 " 620	=	964
3d S. S.		12 " 632	=	952

?.....	98	to 730	=	854
4th S. S..	25	" 755	=	829
?.....	77	" 832	=	752
5th S. S.....pebble at top.	10	" 842	=	742
?.....pocket.	13	" 855	=	729

Wet hole. Cased at 360′.

Best production 10 barrels per day. Half enough gas to fire one boiler. Black oil.

59. *Emory Well, No.* 2. (307)

August, 1869.

Walter Scott Petroleum Company's tract, adjoining C. Clark Farm, half mile east of Shamburg. Authority, ———.

Well mouth above ocean in feet.....				1641
?.....	900	to 900	=	741
5th S. S.....	18	" 918	=	723
?.....	12	" 930	=	711
6th S. S.....pebble and sand.	35	" 965	=	676
?.....	7	" 972	=	669

Wet hole. Cased at ——.

Best production 80 barrels per day. Gas sufficient to fire one boiler. Green oil.

This well was put down and tested in the 5th S. S., and obtained black oil in small quantities; was afterwards put deeper. This 6th rock is evidently the one called the 5th in Shamburg.

60. *Oak Shade Well, No.* 1. (128)

September 10, 1868.

Clark Farm, ten acre lease, near Shamburg. Authority, George W. Arnold, Supt.

Well mouth above ocean in feet.....				1545
?.....	120	to 120	=	1425
1st S. S.....	93	" 213	=	1332
?.....	117	" 330	=	1215
2d S. S.....	30	" 360	=	1185
?.....	226	" 586	=	959
3d S. S.....	14	" 600	=	945
?.....	104	" 704	=	841
4th S. S.....	13	" 717	=	828
?.....	83	" 800	=	745
5th S. S.....pebble and sand.	65	" 865	=	680

Wet hole. Cased at 345′. Pumped 23′ from bottom.

Best production 40 barrels per day. No gas of any account. Black oil. Gravity 36° or 37°. Mud veins at 590′ and 850′.

This well was not drilled through the 5th S. S. From other wells near

by we judge there remain 15′ more of sand, which would make the entire thickness of the sand 65′ + 15′ = 80′. The well from the time it was struck has averaged 25 barrels per day. [Jan. 1869.]

61. *Lady Jane Well, No.* 1. (129)

December 13, 1868.

Clark Farm, 5 acre lease, near Shamburg. Authority, Arnold & Lockwood.

Well mouth above ocean in feet				1539
?	120	to	120	= 1419
1st S. S.	116	"	236	= 1303
?	90	"	326	= 1213
2d S. S.	39	"	365	= 1174
?	213	"	578	= 961
3d S. S.	22	"	600	= 939
?	98	"	698	= 841
4th S. S.	36	"	734	= 805
?	66	"	800	= 739
5th S. S. pebble and sand	73	"	873	= 666

Wet hole. Cased at 347′. Pumped 22′ from bottom.

Best production 20 barrels per day. Not gas enough to fire a boiler. Black oil. Gravity 36° or 37°. Mud veins at 340′, 720′, 810′, and 850′. The well was not drilled through the 5th sand by 15′ or 20′. Small division of slate in this sand.

62. *Lockwood Well, No.* 1. (131)

September 20, 1866.

Clark Farm, near Shamburg. Authority, E. M. & T. J. Lockwood.

Well mouth above ocean in feet				1492
?	103	to	103	= 1389
1st S. S.	40	"	143	= 1349
?	139	"	282	= 1210
2d S. S.	29	"	311	= 1181
?	219	"	530	= 962
3d S. S.	7	"	537	= 955
?	105	"	642	= 850
4th S. S.	35	"	677	= 815
?	108	"	785	= 707
5th S. S. pebble and sand	46	"	831	= 661
? pocket	11	"	842	= 650

Wet hole. Cased at 300′. Pumped 40′ from bottom.

Best production 6 barrels per day. Half enough gas to fire one boiler. Color of oil between black and green. Gravity 37°. Mud vein at 645′.

The Lockwood Well showed evidences of being on the outskirts of the black oil bearing rock, as it produced a large quantity of salt water, and the Shamburg well in close proximity produced light green oil.

63. *Fink Well.* (127)

February 22, 1867.

On lease No. 12, Pittsburgh and Cherry Run Oil Company, Shamburg. Authority, John J. B. Fink.

Well mouth above ocean in feet				1500
?	70	to	70	= 1430
1st S. S.....white sand, 60′, gray sand 22′ =	82′	"	152	= 1348
?	137	"	289	= 1211
2d S. S., white sand and pebbles 16′, gray sand 30′=	46	"	335	= 1165
?	185	"	520	= 980
3d S. S.	25	"	545	= 955
?	95	"	640	= 860
4th S. S....pebbly at top, bottom fine and white	28	"	668	= 832
?	108	"	776	= 724
5th S. S.....loose open rock.	57′	"	833	= 667
? .....pocket.	2	"	835	= 665

Wet hole. Cased at 340′. Pumped 15′ from bottom.

Best production, 210 barrels per day. Green oil. Gravity 48°. Gas sufficient to fire from 4 to 6 boilers. Mud veins at 530′, 645′ and 806′. Crevice at 778′.

We are troubled a great deal with mud running into the well at 806′. The well is still producing, and could be made to pump 20 barrels per day if we could exhaust the mud, and keep the well clean [Jan. 1st, 1869].

There are shells ranging in thickness, between the regular Sandrocks which I could not give in this blank.

64. *Fink Well, No.* 1. (147)

May 5th, 1867.

Farm of Huidekoper Petroleum Co. of N. Y., lease No. 1, 10 acres, Shamburg. Authority, John J. B. Fink.

Well mouth above ocean in feet				1510
?	100	to	100	= 1410
1st S. S.	72	"	172	= 1338
?	126	"	298	= 1212
2d S. S.	24	"	322	= 1188
?	206	"	528	= 982
3d S. S.	33	"	561	= 949
?	96	"	657	= 853
4th S. S.	42	"	699	= 811
?	95	"	794	= 716
5th S. S.....pebble at top and bottom.	49	"	843	= 667

Wet hole. Cased at 325′. Pumped 15′ from bottom.

Best production 75 barrels per day. Gas sufficient to fire 2 boilers. Light green oil. Gravity 46° to 47°.

The oil rock has a 7′ shell above it.

This well was finished May 3d, 1867. The well will produce an average

of from 10 to 15 barrels per day now, January, 1869. I have two more wells on this same lease, and their records do not vary much from this one. One is now averaging from 25 to 40 barrels per day, and the other about 6 barrels.

65. *Fee Well, No.* 1. (139)

December 23, 1867.

Atkinson Farm, lease 106, Shamburg. Authority, F. E. Hammond.

Well mouth above ocean in feet					1533
?		817	to	817	= 716
5th S. S.	pebble and sand.	45	"	862	= 671

Wet hole. Not cased. Seed bag at 322′. Pumped 20′ from bottom.

Best production 512 barrels per day. Gas sufficient to fire 6 boilers. Green oil. Gravity 47½°.

This well ceased producing October, 1868. The total production was 49,262 11/100 barrels. The largest production was in the month of May, being 11,200 barrels.

66. *Jack Brown Well, No.* 1. (140)

December 27th, 1867.

Atkinson Farm, lease 108, Shamburg. Authority, F. E. Hammond.

Well mouth above ocean in feet					1533
?		98	to	98	= 1435
1st S. S.		100	"	198	= 1335
?		112	"	310	= 1223
2d S. S.		25	"	335	= 1198
?		221	"	556	= 977
3d S. S.		13	"	569	= 964
?		110	"	679	= 854
4th S. S.		25	"	704	= 829
?		111	"	815	= 718
5th S. S.	pebble and sand.	40	"	855	= 678

Wet hole. Cased at 320′. Pumped 3′ from bottom.

Best production 441 barrels per day. Gas supplied at one time 15 boilers. Green oil. Gravity 47½°. Mud vein at 830′.

This well ceased to produce August 17th, 1868. The total production was 65,916 7/10 barrels, averaging 284 13/100 barrels per day from the commencement of production to the close. The average price paid for this oil was $2.52 per barrel at the well. During the month of April, 1868, it produced 14,500 barrels, and the same was delivered to Pipe Co., averaging 483⅓ barrels daily.

67. *Skinner Well, No* 1. (142)

April, 1868.

Lease No. 100, Atkinson Farm, Shamburg. Authority, F. E. Hammond.

Well mouth above ocean in feet					1537
?		101	to	101	= 1436
1st S. S.		100	"	201	= 1336
?		110	"	311	= 1226
2d S. S.		25	"	336	= 1201
?		222	"	558	= 979
3d S. S.		13	"	571	= 966
?		199	"	770	= 767
4th S. S.		25	"	795	= 742
?		23	"	818	= 719
5th S. S.	pebble and sand.	45	"	863	= 674
?	pocket.	5	"	868	= 669

Wet hole. Not cased. Seed bag at 330′. Pumped 18′ from bottom.

Best production 150 barrels per day. Gas sufficient to fire 2 boilers. Green oil. Gravity 47½°. Mud vein at 828′.

This well produced 11,611$\frac{38}{100}$ barrels of oil, 43 gallons to the barrel. This was sold at an average price of $3.81 per barrel. Well ceased to produce October, 1868.

68. *Hammond Brothers Well, No.* 1. (144)

January, 1869.

Lease 42, Atkinson Farm, Shamburg. Authority, F. E. Hammond.

Well mouth above ocean in feet					1575
?		142	to	142	= 1433
1st S. S.		100	"	242	= 1333
?		135	"	377	= 1198
2d S. S.		25	"	402	= 1173
?		196	"	598	= 977
3d S. S.		13	"	611	= 964
?		107	"	718	= 857
4th S. S.		40	"	758	= 817
?		100	"	858	= 717
5th S. S.	pebble and sand.	45	"	903	= 672
?	pocket.	7	"	910	= 665

Wet hole. Cased at 375′. Pumped 5′ from bottom.

Best production 40 barrels per day. Half enough gas to fire a boiler. Green oil. Gravity 47½°.

69. *Tallman Farm Well, No. 2.* (135)

November, 1868.

Lease No. 2. Tallman Farm, near Shamburg. Authority, Lyman Stewart.

Well mouth above ocean in feet				1501
?		70 to 70	=	1431
1st S. S.		80 " 150	=	1351
?		140 " 290	=	1211
2d S. S.		15 " 305	=	1196
?		225 " 530	=	971
3d S. S.		25 " 555	=	946
?		110 " 665	=	836
4th S. S.		40 " 705	=	796
?		90 " 795	=	706
5th S. S.	Sandy.	43 " 838	=	663
?	pocket.	14 " 852	=	649

Wet hole. Cased at 300′. Pumped 12′ from bottom.

Best production 8 barrels per day. Gas sufficient to fire one boiler. Green oil. Gravity 46°. Mud veins at 673′ and at 828′.

At 511′ shelly rock; at 643′ crevice of 3″. From 643′ to 671′ we find crevices of from 2″ to 8″, about 10′ apart; at 672′ a broken rock, and at 677′ a small crevice; at 770′ a crevice of 3″; at 788′ rough rock. From 801′ to 804′ pebble rock. 5th S. S. rough and broken, with small crevices. No discovery of effects of torpedo on rock, neither did they (we put in 5) improve materially the production.

NOTE.—The above measurements are taken from Dale's crevice searcher's record, and from the driller's memoranda.

70. *Andrews and Stuart Well, No.* 1. (149)

Lease 86, Tallman Farm, Shamburg. Authority, ———.

Well mouth above ocean in feet				1532
?		85 to 85	=	1447
1st S. S.		80 " 165	=	1367
?		145 " 310	=	1222
2d S. S.		35 " 345	=	1187
?		205 " 550	=	982
3d S. S.		15 " 565	=	967
?		115 " 680	=	852
4th S. S.		40 " 720	=	812
?		90 " 810	=	722
5th S. S.	pebble.	50 " 860	=	672

Wet hole. Cased at 320′. Pumped 4′ from bottom.

Best production 300 barrels per day. Gas sufficient to fire 5 boilers. Green oil. Gravity 48° to 45°. Mud veins at 688′, 712′, 820′ and 850′.

71. *Chatfield and Tomlinson Well, No* 1. (183)

March, 1867.

Lease No. 12, Henderson Farm, Upper Cherry Run, half mile south of Shamburg. Authority, Chatfield and Tomlinson

Well mouth above ocean in feet				1530
?	100	to	100	= 1430
1st S. S	95	"	195	= 1335
?	135	"	330	= 1200
2d S. S	30	"	360	= 1170
?	290	"	650	= 880
3d S. S	20	"	670	= 860
?	30	"	700	= 830
4th S. S	40	"	740	= 790
?	55	"	795	= 735
5th S. S. pebble and white sand.	56	"	851	= 679

Wet hole. Cased with 3 inch casing at 325′. Pumped 8′ from bottom.

Best production 15 barrels per day. Gas sufficient to fire 1 boiler. Green oil. Gravity 47° to 48°.

The 5th S. S. was close and white with a pebble stratum about 20′ from the top.

This farm produces black oil on its east side, from 40 to 60 rods from this well.

72. *Nell Well*, (189)

August, 1865.

Great Republic Farm, 1 mile south of Shamburg. Authority, Thomas H. Gamble.

Well mouth above ocean in feet				1410
?	40	to	40	= 1370
1st S. S	20	"	60	= 1350
?	190	"	250	= 1160
2d S. S	25	"	275	= 1135
?	195	"	470	= 940
3d S. S	12	"	482	= 928
?	118	"	600	= 810
4th S. S	40	"	640	= 770
?	95	"	735	= 675
5th S. S. sand, grey.	10	"	745	= 665
? pocket.	35	"	780	= 630

Wet hole. Cased at 352′. Pumped 15′ from bottom.

Production ———. Black oil; very little gas.

73. *Sassafras Well, No.* 1. (191)

January, 1869.

Beatty Farm, lease No. 48, 1½ miles south-west of Shamburg, at the head of Bull Run, on the upper side of the Titusville and Plumer road. Authority, Phil. Beckman.

Well mouth above ocean in feet				1511
?	400	to	400	= 1111
1st S. S.	50	"	450	= 1061
?	128	"	578	= 933
2d S. S.	30	"	608	= 903
?	92	"	700	= 811
3d S. S.	34	"	734	= 777
?	126	"	860	= 651
4th S. S.	14	"	874	= 637
?pocket.	6	"	880	= 631

Wet hole. Cased at 604′. Pumped 8′ from bottom.

Black oil. This well was being tested when the record was being given and at that time made a good show of black oil.

74. *Rensselear Oil Company's Well, No.* 10. (246)

February 12, 1867.

On Lot 29; Beatty Farm, Cow Run, property of Clinton Oil Company, 1½ miles south-west of Shamburg. Authority, N. J. Tompkins, Supt.

Well mouth above ocean in feet				1172
Surface sand	25	to	25	= 1147
?	260	"	285	= 887
1st S. S.	11	"	296	= 876
?	92	"	388	= 784
2d S. S.	25	"	413	= 759
?	105	"	518	= 654
3d S. S.white sand and pebble.	27	"	545	= 627
?pocket.	2	"	547	= 625

Wet hole. Cased at 392′ with 3 inch casing. Gas sufficient to fire 2 boilers

Best production 20 barrels per day. Green oil. Gravity 47°.

This well has been producing over two years and has averaged 16 barrels per day during that time. It is now pumping 10 barrels per day [Feb. 26th, 1869].

75. *Vicker and Russell Well.* (192)

January, 1867.

Patterson Farm, 1 mile east of Pioneer. Authority, ———.

Well mouth above ocean in feet				1403
?	712	to	712	= 691
4th S. S.	12	"	724	= 679

?.....	101	to	825	= 578
5th S. S.....	25	"	850	= 553

Wet hole. While drilling this well deeper in hopes of finding a sand-bearing green oil, the tools stuck, and the well was abandoned at the depth of 850′.

IV. *Wells along Oil Creek Valley, from Foster's Farm to Oil City.*

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76. *Sherman Well, No.* 1. (276)

1861.

On Foster Farm, Oil Creek, three-quarters of a mile above Pioneer. Authority, Josephus Chandler.

Well mouth above ocean in feet.....				1092
?.....	147	to	147	= 945
1st S. S.....	18	"	165	= 927
?.....	132	"	297	= 795
2d S. S.....	15	"	312	= 780
?.....	118	"	430	= 662
3d S. S.....sand and pebble.	36	"	466	= 626
?.....pocket.	14	"	480	= 612

Wet hole. Seed-bagged on tubing at 300′.

Best production 1200 barrels per day. Green oil. Gravity 45° to 48°.

Gas sufficient to fire 12 boilers.

77. *Porter Well, No.* 1. (231)

1865.

On Foster Farm, on the bank of Oil Creek, above Pioneer. Authority?

Well mouth above ocean in feet.....				1096
?.....	150	to	150	= 946
1st S. S.....	8	"	158	= 938
?.....	150	"	308	= 788
2d S. S.....	20	"	328	= 768
?.....	90	"	418	= 678
3d S. S.....	30	"	448	= 648

Wet hole. Seed-bagged on tubing.

Best production 200 barrels per day. Green oil.

This well had a connection with the Grand Trunk Well, about ten rods distant from it. When the water was let into the latter well, by drawing the tubing, this well stopped flowing. But when the tubing was replaced in the Grand Trunk and the pumps started, the Porter Well would again begin to flow.

78. *Grand Trunk Well.* (232)

1865.

On Foster Farm flats, above Pioneer. Authority, —— Richards.

Well mouth above ocean in feet					1093
?	150	to	150	=	943
1st S. S.	7	"	157	=	936
?	151	"	308	=	785
2d S. S.	20	"	328	=	765
?	90	"	418	=	675
3d S. S. coarse sand and pebble.	30	"	488	=	645

Wet hole. Seed-bagged on tubing at 310′.
Best production 40 barrels per day. Green oil. Gravity 45°.

79. *Foster Well, No.* 61. (228)

January 1868.

On lease No. 61, Foster Farm, Pioneer. Authority, —— Bishop.

Well mouth above ocean in feet					1392
?	624	to	624	=	768
2d S. S.	12	"	636	=	756
?	96	"	732	=	660
3d S. S. white sand and pebble.	38	"	770	=	622
? pocket.	5	"	775	=	617

Wet hole. Cased at 630′. Gas sufficient to fire 2 boilers. Best production 30 barrels per day.

80. *Bishop Well.* (229)

1867.

On Foster Farm, near Pioneer. Authority, ——.

Well mouth above ocean in feet					1354
?	20	to	20	=	1334
1st S. S.	100	"	120	=	1234
?	436	"	556	=	798
2d S. S.	14	"	570	=	784
?	120	"	690	=	664
3d S. S. slate, sand, and pebble.	35	"	725	=	629
? pocket	10	"	735	=	619

Wet hole. Cased at 560′. Half enough gas to fire a boiler.
Best production 4 barrels per day. Green oil. Gravity 49°.

81. *Foster Well. Lease* 37. (230)

March, 1867.

On Foster Farm, near Pioneer. Authority, —— Bishop.

Well mouth above ocean in feet				1354
?	562	to	562	= 792
2d S. S	10	"	572	= 782
?	118	"	690	= 664
3d S. S.....coarse white sand and pebble.	38½	"	728½	= 625½

Wet hole. Cased at 567′. Gas sufficient to fire one boiler.
Best production 90 barrels per day. Green oil. Gravity 49°.

82. *Well No.* 1, *Lease No.* 2. (240)

July, 1867.

On the Wood Farm, near Petroleum Centre. Authority, J. A. Wharry.

Well mouth above ocean in feet				1475
?	250	to	250	= 1225
1st S. S	45	"	295	= 1180
?	240	"	535	= 940
2d S. S	50	"	585	= 890
?	130	"	715	= 760
3d S. S	20	"	735	= 740
?	77	"	812	= 663
4th S. S.....sand and pebble.	47	"	859	= 616

Wet hole. Cased at 540′. Gas sufficient to fire 16 boilers
Flowing well. Best production 150 barrels per day. Green oil. Gravity 43°.

83. *George K. Anderson Well.* Lease No. 21. (242)

February 14, 1868.

On Wood Farm, near Petroleum Centre. Authority, J. A. Wharry.

Well mouth above ocean in feet				1534
?	615	to	615	= 919
2d S. S	50	"	665	= 869
?	75	"	740	= 794
3d S. S	10	"	750	= 784
?	136	"	886	= 648
4th S. S.....pebble.	45	"	931	= 603
?.....pocket.	49	"	980	= 554

Wet hole. Cased at 660′. Pumped 55′ feet from bottom.
This well was unproductive. It is situated on the highest hill on the Wood Farm.

84. *George K. Anderson Well, Lease No.* 5. (243)

April, 1868.

On Wood Farm, near Petroleum Centre. Authority, J. A. Wharry.

Well mouth above ocean in feet					1487
?	565	to	565	=	922
2d S. S	45	"	610	=	877
?	110	"	720	=	767
3d S. S	8	"	728	=	759
?	107	"	835	=	652
4th S. S. sand and pebble.	45	"	880	=	607
? pocket	1	"	881	=	606

Wet hole. Cased at ——. Gas sufficient to fire 2 boilers.
Best production 40 barrels per day.

85. *George K. Anderson Well, Lease No.* 33. (245)

February 12, 1868.

On Samuel Wood Farm, near Petroleum Centre. Authority, J. A. Wharry.

Well mouth above ocean in feet					1498
?	570	to	570	=	928
2d S. S	50	"	620	=	878
?	75	"	695	=	803
3d S. S	6	"	701	=	797
?	143	"	844	=	654
4th S. S. sand and pebble.	53	"	897	=	601
? pocket.	15	"	712	=	586

Wet hole. Cased at 611′. Pumped 17′ feet from bottom. Gas sufficient to fire 2 boilers.
Best production 20 barrels per day. Green oil. Gravity 43°.

86. *Well No.* 1, *Lease* 36. (219)

On Stevenson Farm, at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet					1368
?	457	to	457	=	911
1st S. S	13	"	470	=	898
?	105	"	575	=	793
2d S. S	2	"	577	=	791
?	140	"	717	=	651
3d S. S	45	"	762	=	606
? pocket.	10	"	772	=	596

87. *Well No* 1, *Lease* 51. (220)

On Stevenson Farm, at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet				1350
?	428	to 428	=	922
1st S. S.	6	" 434	=	916
?	145	" 579	=	771
2d S. S.	30	" 609	=	741
?	83	" 692	=	658
3d S. S.	46	" 738	=	612

88. *Pinner Well.* (221)

February, 1867.

On Robert Stevenson's Farm, about one mile north of Petroleum Centre. Authority, ———.

Well mouth above ocean in feet				1369
?	200	to 200	=	1169
1st S. S.	40	" 240	=	1129
?	200	" 440	=	929
2d S. S.	15	" 455	=	914
?	256	" 711	=	658
3d S. S. ....sand and pebble.	40	" 751	=	618
? ....pocket.	14	" 765	=	604

Wet hole. Cased at 450′.

Best production 25 barrels per day. Green oil. Gravity 47°. Gas sufficient to fire 2 boilers.

This well is one of those that need some appliance to draw the gas from the well. We are now [Feb. 12, 1869] using a rotary pump, which not only increases the amount of gas, but helps the production. This well is producing as well as it was two years ago (in 1867).

89. *Well No.* 1, *Lease* 134. (213)

On Central Petroleum Co.'s land at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet				1106
?	193	to 193	=	913
1st S. S.	47	" 240	=	866
?	105	" 345	=	761
2d S. S.	7	" 352	=	754
?	123	" 475	=	631
3d S. S.	39	" 514	=	592
? ....pocket.	52	" 566	=	540

90. *Well No.* 1, *Lease* 305. (214)

On Central Petroleum Co.'s land at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet				1257
?	340	to 340	=	917
1st S. S.	50	" 390	=	867
?	103	" 493	=	764
2d S. S.	7	" 500	=	757
?	110	" 610	=	647
3d S. S.	48	" 658	=	599
? pocket.	20	" 678	=	579

91. *Well No.* 1, *Lease* 306. (215)

On Central Petroleum Co.'s land at Petroleum Centre Authority, Geo K. Anderson.

Well mouth above ocean in feet				1234
?	316	to 316	=	918
1st S. S.	48	" 364	=	870
?	108	" 472	=	762
2d S. S.	7	" 479	=	755
?	111	" 590	=	644
3d S. S.	46	" 636	=	598
? pocket.	12	" 648	=	586

92. *Well No.* 1, *Lease* 37. (217)

On Stevenson Farm, at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet				1372
?	459	to 459	=	913
1st S. S.	13	" 472	=	900
?	105	" 577	=	795
2d S. S.	2	" 579	=	793
?	140	" 719	=	653
3d S. S.	45	" 764	=	608
? pocket	29	" 793	=	579

93. *Swamp Angel* Well, No.* 3. (247)

On lease No. 141, Central Petroleum Co.'s land at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet				1092
?	185	to 185	=	907
1st S. S.	15	" 200	=	892

* It would puzzle an antiquary of the next century to explain this name; but as it was taken from the army sobriquet of the huge piece of ordnance used before Fort Sumter, the name of the well enables us to assign as its probable date 1861.

?	133	to 333	=	759
2d S. S	6	" 339	=	753
?	121	" 460	=	632
3d S. S	43	" 503	=	589
?.....pocket.	45	" 548	=	544

94. *Swamp Angel Well, No.* 4. (248)

On lease No. 141, Central Petroleum Co.'s land at Petroleum Centre. Authority, Geo. K. Anderson.

Well mouth above ocean in feet..... 1094

?	160	to 160	=	934
1st S. S	40	" 200	=	894
?	140	" 340	=	754
2d S. S	6	" 346	=	748
?	119	" 465	=	629
3d S. S	45	" 510	=	584
	42	" 552	=	542

95. *Abbe and Bailey Well.* (283)

1866.

On lease 156, Central Petroleum Co.'s land at Petroleum Centre. Authority ———.

Well mouth above ocean in feet..... 1093

?	190	to 190	=	903
1st S. S	42	" 232	=	861
?	108	" 340	=	753
2d S. S	20	" 360	=	733
?	103	" 463	=	630
3d S. S	40	" 503	=	590

Wet hole. Seed-bag at 350′.

Gas sufficient to fire 1 boiler. Mud vein at 340′.

Best production 15 barrels per day.

96. *Abbe and Bailey Well.* (285)

1865.

On lease 179, Central Petroleum Co.'s land at Petroleum Centre. Authority, ———.

Well mouth above ocean level..... 1093

?	185	to 185	=	908
1st S. S	45	" 230	=	863
?	110	" 340	=	753
2d S. S	20	" 360	=	733
?	105	" 465	=	628
3d S. S.....sand and pebble.	40	" 505	=	588
?.....pocket.	28	" 533	=	560

Wet hole. Cased at 350′. Gas sufficient to fire 1 boiler. Mud vein at 464′.

Best production 75 barrels per day. Green oil. Gravity 46°.

97. *Mary Ann Well.* (223)

April, 1868.

On lease No. 24, Bennehoff Farm, on the bluff between Petroleum Centre and Pioneer. Authority, Edward E. Partridge.

Well mouth above ocean in feet					1397
?	473	to	473	=	924
1st S. S.	11	"	484	=	913
?	139	"	623	=	774
2d S. S.	12	"	635	=	762
?	104	"	739	=	658
3d S. S. pebble and sand.	41	"	780	=	617

Wet hole. Cased at 624'. Pumped 4 feet from bottom. Mud vein on top of 3d S. S. Best production 120 barrels per day. Green oil. Gravity 46°. Gas sufficient to fire 1 boiler. Blower attached as soon as the water was exhausted.

There is a surface sand about 60 feet from the top, and a mountain sand about 100 feet below the surface sand, about 65 feet thick. I believe that wells on the flat do not find either of the above sands. On the hill, we call the sands, first, second, and third sands. Some seed-bag in the 1st sand. I think that the majority of the wells on this farm are seed-bagged in the first sand.

98 *Harding and Jones Well.* (225)

February 7, 1869.

On lease No. 9, Bennehoff Farm, on the bluff between Petroleum Centre and Pioneer. Authority, N. Jones.

Well mouth above ocean in feet					1445
?	300	to	300	=	1145
1st S. S.	30	"	330	=	1115
?	185	"	515	=	930
2d S. S.	10	"	525	=	920
?	100	"	625	=	820
3d S. S.	20	"	645	=	800
?	133	"	778	=	667
4th S. S. sand and pebble.	49	"	827	=	618
? pocket.	8	"	835	=	610

Wet hole. Cased at 520'. Pumped 6 feet from the bottom. Mud vein at 820'. Gas sufficient to fire one boiler.

Best production 50 barrels per day. Green oil. Gravity 47°.

99 *Courts and Andrews Well.* (226)

July 30, 1869.

On lease No. 8, Bennehoff Farm, on the bluff between Petroleum Centre and Pioneer. Authority, T. I. Thompson, Agent.

Well mouth above ocean in feet					1435
?		60	to	60	= 1375
1st S. S		30	"	90	= 1345
?		412	"	502	= 933
2d S. S		10	"	512	= 923
?		125	"	637	= 798
3d S. S		8	"	645	= 790
?		124	"	769	= 666
4th S. S	pebble.	43	"	812	= 623

Wet hole. Cased at 504′. Pumped 4′ from bottom. Mud vein at 808′. Gas sufficient to fire 2 boilers.

Best production 180 barrels per day. Green oil. Gravity 48°.

100. *Stuart Well.* (227)

September 1868.

On lease No. 7, Bennehoff Farm, on the bluff between Petroleum Centre and Pioneer. Authority, John Waddell.

Well mouth above ocean in feet					1405
?		60	to	60	= 1345
1st S. S		70	"	130	= 1275
?		420	"	550	= 855
2d S. S		20	"	570	= 835
?		48	"	618	= 787
3d S. S		14	"	632	= 773
?		108	"	740	= 665
4th S. S	sand and pebble.	40	"	780	= 625
?	pocket.	2	"	782	= 623

Wet hole. Cased at 554′. Pumped 4′ from bottom. Mud vein at 744′.

Best production 14 barrels per day. Green oil. Gravity 44°.

101. *Blocker Well.* (249)

June, 1868.

Columbia Oil Company's "Story Farm," Oil Creek. Authority, George Boulton, Supt.

Well mouth above ocean in feet					1120
?		240	to	240	= 880
1st S. S		20	"	260	= 860
?		115	"	375	= 745
2d S. S		31	"	406	= 714

?.....		113	to	519	= 601
3d S. S.....	pebble and sand.	52	"	571	= 549
?.....	pocket.	1	"	572	= 548

Wet Hole. Cased at 500′. Pumped 8′ from bottom.

Best production 175 barrels per day. Gas sufficient to fire 1 boiler. Green oil. Gravity 47°. No mud veins.

102. *Babcock Well.* (250)

July, 1866.

Columbia Oil Company's "Story Farm," Oil Creek. Authority, George Boulton, Supt.

Well mouth above ocean in feet.....					1223
?..		345	to	345	= 878
1st S. S.....		41	"	386	= 837
?.....		89	"	475	= 748
2d S. S.....		25	"	500	= 723
?.....		95	"	595	= 628
3d S. S.....	pebble and sand.	47	"	642	= 581
?.....	pocket.	5	"	647	= 576

Wet hole. Not cased. Seed bag at 485′. Pumped 10′ from bottom.

Best production 165 barrels per day. Gas sufficient to fire 3 boilers. Green oil. Gravity 47°. Mud vein at 598′.

03. *Goe Well.* (251)

———— ———— ————.

Columbia Oil Company's "Story Farm," Oil Creek. Authority, George Boulton, Supt.

Well mouth above ocean in feet.....					1256
?.....		380	to	380	= 876
1st S. S.....		32	"	412	= 844
?.....		108	"	520	= 736
2d S. S.....		27	"	547	= 709
?.....		98	"	645	= 611
3d S. S.....	pebble and sand.	42	"	687	= 569
?.....	pocket.	6	"	693	= 563

Wet hole. Not cased. Seed bag at 530′. Pumped 12′ from bottom.

Best production 120 barrels per day. Gas sufficient to fire one boiler Green oil. Gravity 47°. Mud vein at 647′.

104. *Reiter Well.* (252)

Columbia Oil Company's "Story Farm," Oil Creek. Authority, George Boulton, Supt.

Well mouth above ocean in feet.					1291
?		420	to	420	= 871
1st S. S.		35	"	455	= 836
?		100	"	555	= 736
2d S. S.		24	"	579	= 712
?		94	"	673	= 618
3d S. S.	pebble and sand.	44	"	717	= 574
?	pocket.	5	"	722	= 569

Wet hole. Cased at 565′. Pumped 8′ from bottom.

Best production 55 barrels per day. Gas sufficient to fire 5 boilers. Green oil. Gravity 47°. Mud vein at 676′.

105. *Boulton Well.* (253)

October, 1868.

Columbia Oil Company's "Story Farm," Oil Creek. Authority, George Boulton, Supt.

Well mouth above ocean in feet.					1374
?		462	to	462	= 912
1st S. S.		40	"	502	= 872
?		98	"	600	= 774
2d S. S.		20	"	620	= 754
?		122	"	742	= 632
3d S. S.	pebble and sand.	47	"	789	= 585
?	pocket.	5	"	794	= 580

Wet hole. Cased at 470′. Pumped 8′ from bottom.

Best production 12 barrels per day. Gas sufficient to fire one boiler. Green oil. Gravity 47°. No mud vein.

106. *Story Centre Well, No.* 1. (284)

July, 1863.

On lease No. 27, Columbia Oil Co.'s Story Farm, Oil Creek. Authority, George Boulton, Supt.

Well mouth above ocean in feet.					1065
?		200	to	200	= 865
1st S. S.		40′	"	240	= 825
?		90	"	330	= 735
2d S. S.		31′	"	361	= 704
?		104	"	465	= 600
3d S. S.	sand and pebble.	47′	"	512	= 553

Wet hole. Seed bagged on tubing at 330′. Pumped 10′ from bottom. Gas sufficient to fire 3 boilers.

Best production 250 barrels per day. Green Oil. Gravity 46°.

107. *Phillips Well, No. 2.* (255)

1861.

Tarr Farm, Oil Creek, 2 miles above Rouseville. Authority, ———.

Well mouth above ocean in feet				1057
?	10	to	10	= 1047
Mountain sand	70	"	80	= 977
?	100	"	180	= 877
1st S. S.	30	"	210	= 847
?	111	"	321	= 736
2d S. S.	27	"	348	= 709
?	77	"	425	= 632
Sandy shell	2	"	427	= 630
Slate	4	"	431	= 626
"Gray rock"	40	"	471	= 586
3d S. S. not through	10	"	481	= 576

Best production 3,940 barrels per day, by actual measurement. Green oil. Gravity 46°. Mud vein at 466′. Size of hole 4 inches. Tubed with 2¼ in. tubing without a working barrel.

This well has produced over 600,000 barrels of oil to present date (March 1, 1869), which has been sold at from 10 cents to $14.50 per barrel at the well.

It started to flow before drilling was completed and threw out the water and oil so furiously that the tubing could not be put in to shut off the water for three days, and even then the tubing had to be chained down to keep it from being blown out of the hole.

The well was lately searched by "Dale's crevice searcher," which reported a crevice of 3 inches at the depth of 472 7/12 feet.

108. *Union Well.* (254)

1862.

Tarr Farm, Oil Creek. Authority, ———.

Well mouth above ocean in feet				1066
?	195	to	195	= 871
1st S. S.	30	"	225	= 841
?	100	"	325	= 741
2d S. S.	25	"	350	= 716
?	130	"	480	= 586
3d S. S. pebble and sand.	30	"	510	= 556

Wet hole. Not cased.

Best production 200 barrels per day. Green oil. Gravity 47°.

109. *Lynn Well, No.* 2. (256)

November, 1867.

Lease No. 192, Tarr Farm, Oil Creek. Authority, J. H. Dilks.

Well mouth above ocean in feet					1231
?		100	to	100	= 1131
1st S. S		80	"	180	= 1051
?		240	"	420	= 811
2d S. S		20	"	440	= 791
?		90	"	530	= 701
3d S. S		32	"	562	= 669
?		75	"	637	= 594
4th S. S	pebble and sand.	42	"	679	= 552

Wet hole. Cased at 607′. Pumped 7′ from bottom.

Best production 60 barrels per day. Gas sufficient to fire 3 boilers. Green oil. Gravity 47°.

This well was torpedoed at 649′ and 664′. The production before was 15 barrels, afterwards 40 barrels.

110. *Sterling Well.* (275)

1864–5.

On Tar Farm, Oil Creek above Rouseville. Authority, Ambrose John Moran.

Well mouth above ocean in feet					1052
?		195	to	195	= 857
1st S. S		30	"	225	= 827
?		85	"	310	= 742
2d S. S		30	"	340	= 712
?		120	"	460	= 592
3d S. S	sand and pebble.	35	"	495	= 557

Wet hole. Cased at 320′. Pumped 1′ from bottom.

Best production 200 barrels per day. Green oil. Gravity 44°. Gas sufficient to fire 3 boilers. Mud vein at 465′.

111. *Byron Mitchell Well, No.* 1. (257)

November, 1868.

Lease No. 258, Blood Farm, Oil Creek, 1½ miles north of Rouseville. Authority, S. Hyland.

Well mouth above ocean in feet					1309
?		685	to	685	= 624
2d S. S		29	"	714	= 595
?		1	"	715	= 594

3d S. S.	pebble and sand.	40	to 755	=	554
?	pocket.	3	" 758	=	551

Wet hole. Cased at 685′.

Best production 120 barrels per day. Gas sufficient to fire 1 boiler. Green Oil. Gravity 44°.

This well was doing 20 barrels when a torpedo was exploded in it, which had a damaging effect, reducing the production to 8 barrels.

112. *Lady Suffolk Well.* (258)

June, 1868.

Lease No. 240, Blood Farm, Oil Creek, 1½ miles north of Rouseville. Authority, A. B. Mudge.

Well mouth above ocean in feet					1334
?		465	to 465	=	869
1st S. S.		40	" 505	=	829
?		105	" 610	=	724
2d S. S.		26	" 636	=	698
?		61	" 697	=	637
3d S. S	"gray rock."	25	" 722	=	612
?		24	" 746	=	588
4th S. S.	pebble and sand.	37	" 783	=	551

Wet hole. Cased at 706′. Pumped 7′ from bottom.

Best production 85 barrels per day. Gas sufficient to fire 2 boilers. Green oil. Gravity 45°.

113. *Ætna Well.* (259)

———— ———— ————.

Lease No. 18, Rynd Farm, Oil Creek, 1 mile north of Rouseville. Authority, George K. Anderson.

Well mouth above ocean in feet					1043
?		190	to 190	=	853
1st S. S.		28	" 218	=	825
?		114	" 332	=	711
2d S. S.		18	" 350	=	693
?		115	" 465	=	578
3d S. S.		32	" 497	=	546
?	pocket.	14	" 511	=	532

114. *Pacific Well, No.* 1. (260)

January, 1863.

Lease No. 17, Rynd Farm, Oil Creek, 1 mile north of Rouseville. Authority, Hendrickson and Walker.

Well mouth above ocean in feet					1045
?		195	to 195	=	850

1st S. S.		25	to 220	=	825
?		115	" 335	=	710
2d S. S.		28	" 363	=	682
?		110	" 473	=	572
3d S. S.		35	" 508	=	537
?	pocket.	7	" 515	=	530

Wet hole. Not cased. Seed-bag at 460′.

Best production 12 barrels per day. Gas sufficient to fire 1 boiler. Green oil. Gravity 45°.

On the Blood and Rynd Farms there is a gray S. S. lying immediately over the third rock. Most operators think that this gray sand is an oil producing rock.

115. *Well No.* 23. (261)

August, 1867.

Rynd Farm, Oil Creek, 1 mile north of Rouseville. Authority, Supt. of of Rynd Farm.

Well mouth above ocean in feet					1043
?		188	to 188	=	855
1st S. S.		23	" 211	=	832
?		117	" 328	=	715
2d S. S.		26	" 354	=	689
?		121	" 475	=	568
3d S. S.	pebble and sand.	28	" 503	=	540
?	pocket.	10	" 513	=	530

Wet hole. Not cased. Seed-bag at 190′.

Best production 10 barrels per day. Green oil. Gravity 46°.

There never was an instance on this farm of one well interfering with another. All the wells producing to-day are pumping oil only. No advantage is gained in the amount of gas by the use of casing, and casing is not much used on the farm. [March 2d, 1869].

116. *Keir Well, No.* 1. (262)

1862.

Rynd Farm, Oil Creek, 1 mile north of Rouseville. Authority, ———.

Well mouth above ocean in feet					1040
?		191	to 191	=	849
1st S. S.		23	" 214	=	826
?		117	" 331	=	709
2d S. S.		26	" 357	=	683
?		121	" 478	=	562
3d S. S.	pebble and sand.	30	" 508	=	532

Wet hole.

Best production 250 barrels per day. Green oil. Gravity 45°.

This well flowed while being drilled, from the 2d rock, or at 357′. We

tubed in this sand and the well yielded 250 barrels per day for some time, but we spoiled it by shutting off the flow by a stop cock; well was afterwards put deeper, but no increase of oil.

117. *Emory Well, No* 1. (263)

January, 1865.

A. Buchanan Farm, on Cherry Run, ½ mile above Rouseville. Authority, A. A. Emory.

Well mouth above ocean in feet.....				1056
?.....	212	to	212	= 844
1st S. S.....	37	"	249	= 807
?.....	106	"	355	= 701
2d S. S.....	30	"	385	= 671
?.....	111	"	496	= 560
3d S. S.....pebble and sand.	34	"	530	= 526
?.....pocket.	13	"	543	= 513

Wet hole. Not cased. Seed-bag at 360′.

Best production 28 barrels per day. Half enough gas to fire a boiler. Green oil. Gravity 43°. Mud vein at 516′.

Very near this well a well was put down which had to be abandoned while drilling in the 2d S. S., but it was pumped for an experiment and produced 900 barrels of dark oil.

118. *Well No.* 13. (264)

December, 1866.

Farm of Union Petroleum Co. of New York, Cherry Run, ¾ of a mile above Rouseville. Authority, E. W. Hinds, Supt.

Well mouth above ocean in feet.....				1086
?.....	221	to	221	= 865
1st S. S.....	67	"	288	= 798
?.....	86	"	374	= 712
2d S. S.....	26	"	400	= 686
?.....	120	"	520	= 566
3d S. S.....pebble and sand.	31	"	551	= 535

Wet hole. Not cased. Seed-bag at 380′.

Green oil. Gravity 46°. The well is now averaging 3 barrels per day [March 3, 1869].

119. *Well No.* 6. (265)

———— ————.

Farm of Union Petroleum Co. of New York, Cherry Run, ¾ of a mile above Rouseville. Authority, E. W. Hinds, Supt.

Well mouth above ocean in feet					1086
?		218	to	218	= 868
1st S. S.		67	"	285	= 801
?		85	"	370	= 716
2d S. S.		32	"	402	= 684
?		118	"	520	= 566
3d S. S.	pebble and sand.	41	"	561	= 525
?	pocket.	29	"	590	= 496

Wet hole. Not cased. Seed bag at 375′.
Green oil. Gravity 46°.

120. *Munson Well.* (267)

October, 1866.

Lease No. 1, Curtin Oil Co.'s tract, on Cherry Run, 1 mile above Rouseville. Authority, ———.

Well mouth above ocean in feet					1103
?		240	to	240	= 863
1st S. S.		32	"	272	= 831
?		108	"	380	= 723
2d S. S.		28	"	408	= 695
?		132	"	540	= 563
3d S. S.	pebble and sand.	34	"	574	= 529
?	pocket.	20	"	594	= 509

Wet hole. Not cased. Seed bag at 410′. Pumped 30′ from bottom.
Best production 120 barrels per day. Gas sufficient to fire 1 boiler. Green oil. Gravity 46°.
This well is near the celebrated Reed Well, and one record will answer for both.

121. *Champion Well, No.* 2. (268)

February, 1868.

Buchanan Farm, Rouseville. Authority, Superintendent of Rouseville Oil Co.

Well mouth above ocean in feet					1047
?		200	to	200	= 847
1st S. S.		33	"	233	= 814
?		117	"	350	= 697
2d S. S.		25	"	375	= 672
?		115	"	490	= 557
3d S. S.		15	"	505	= 542
?	pocket.	15	"	520	= 527

Wet hole. Not cased. Seed bag at 360′.
Best production 100 barrels per day. Gas sufficient to fire 2 boilers.
This well only produced for two days; stopped short off. Think it

pumped what oil it did from the 2d sand. Think it best not to drill through the 3d sand, less likely to get salt water.

122. *Elizabeth Well.* (269)

1862.

Clapp Farm, Oil Creek, between Rouseville and Oil City. Authority?

Well mouth above ocean in feet					1005
?		200	to	200	= 805
1st S. S.		20	"	220	= 785
?		140	"	330	= 645
2d S. S.		15	"	375	= 630
?		85	"	460	= 545
3d S. S.		30	"	490	= 515
?	pocket.	110	"	600	= 405

Wet hole. Cased at 373′.

Best production 100 barrels per day. Green oil.

The well is now being pumped from the 2d S. S.; in pumping a large amount of water with a little oil, perhaps 6 barrels on an average [March 4, 1869].

V. *Wells along the Allegheny River from Oil City to West Hickory.*

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123. *Siverly and Gardner Well.* (270)

1866.

Lease No. 11, Siverly Farm, Allegheny River 1¼ miles above Oil City. Authority, J. W. Gardner, Supt.

Well mouth above ocean in feet					1012
?		260	to	260	= 752
1st S. S.		20	"	280	= 732
?		110	"	390	= 622
2d S. S.		20	"	410	= 602
?		80	"	490	= 522
3d S. S.	pebble and sand.	31	"	521	= 491
?	pocket.	19	"	540	= 472

Wet hole. Cased at 400′.

Best production —. Half enough gas to fire a boiler. Green oil. Gravity 46°.

This well is a fair type of 15 wells on the Siverly farm, which altogether produced 40 barrels per day. They are pumped by heads.

124. *Lowell Well.* (271)

March, 1867.

Howard Oil Association lease, Alcorn Farm, Allegheny River, 3 miles above Oil City. Authority, L. Lowell.

Well mouth above ocean in feet					1016
?	278	to	278	=	738
1st S. S.	8	"	286	=	730
?	70	"	356	=	660
2d S. S.	9	"	365	=	651
?	29	"	394	=	622
3d S. S.	21	"	415	=	601
?	81	"	496	=	520
4th S. S. .shelly.	34	"	530	=	486
?.....pocket.	20	"	550	=	466

Wet hole. Cased at 100′.

Best production 6 barrels per day. Half enough gas to fire a boiler. Green oil. Gravity 42°.

The wells on the river in this locality do not afford much gas.

Torpedoes have been tried in some wells above Oil City with no advantage.

125. *Vandergrift Well, No.* 1. (272)

August, 1868.

On 10 acre tract, by H. McClintock Farm, on Allegheny River, about 3 miles below Oleopolis. Authority, J. J. Vandergrift.

Well mouth above ocean in feet					1039
?	197	to	197	=	842
1st S. S.	20	"	217	=	822
?	74	"	291	=	748
2d S. S.	30	"	321	=	718
?	20	"	341	=	698
3d S. S. ....pebble.	18	"	359	=	680
?.....pocket.	11	"	370	=	669

Wet hole. Seed-bagged on tubing at 120′.

Best production 1 barrel per day. Green oil. Gravity 40°. Half enough gas to fire a boiler.

This well is in the vicinity of a number of wells, all of which are pumping oil from the 2d sand. The oil is of lighter color, but heavier gravity, than the Oil Creek oil. Some of these wells have been pumping for six years [March 5, 1869].

126. *Madden Well.* (273)

1865.

On Anderson Petroleum Co.'s Farm, Allegheny River, ½ mile below the mouth of Pithole Creek. Authority, ———.

Well mouth above ocean in feet	1032

?		160	to	160	= 872
1st S. S.		44	"	204	= 828
?		83	"	287	= 745
2d S. S.	sand and pebble.	18	"	305	= 727
?	pocket.	4	"	309	= 723

Wet hole. Seed-bag at 170′.

Best production 60 barrels per day. Amber oil. Gravity 42°.

It is said that the 3d sand has not been found in this locality, though wells have been drilled 600′ and 800′ deep.

127. *Smith and Schribel Well.* (299)

June, 1869.

Hussey and McBride Farm, Henry's Bend, Allegheny River. Authority, ———.

Well mouth above ocean in feet					1027
?		149	to	149	= 878
1st S. S.		22	"	171	= 856
?		62	"	233	= 794
2d S. S.		10	"	243	= 784
Red slate		11	"	254	= 773
3d S. S.		12	"	266	= 761
?	pocket.	3	"	269	= 758

Wet hole. Cased at 150′.

Best production 8 barrels per day. Amber oil. Gravity 42°.

Another well on the side hill 109′ above this well went through 3d S. S. at 375′. This well is about 10′ above surface of river.

128 *Hunter, Hebert and Carll Well.* (306)

1869.

Hunter Run, ½ mile from Allegheny River, opposite Tionesta, Forest Co. Authority, John F. Carll.

Well mouth above ocean in feet					1092
?		160	to	160	= 932
1st S. S.		8	"	168	= 924
?		90	"	258	= 834
2d S. S.		8	"	266	= 826
?		15	"	281	= 811
3d S. S.		10	"	291	= 801
?		15	"	306	= 786
4th S. S.	coarse pebble in red mud.	15	"	321	= 771
?		116	"	437	= 655

Wet hole. Some oil and gas.

129. *Hamilton Well.* (200)

September, 1869.

Hickory Farm Oil Co., Allegheny River at the mouth of West Hickory Creek, Forest Co. Authority, ———.

Well mouth above ocean in feet				1100
?	100	to	109	= 1000
1st S. S.	25	"	125	= 975
?	35	"	160	= 940
2d S. S. not through.	6½	"	166½	= 933½

Wet hole. Not cased. Seed-bag at 104′.

Best production 60 barrels per day. Green oil. Gravity 33°.

This well, like most others on this and adjoining farms, pumps a large amount of water, which is supposed to come into the well with the oil. November 5, 1869, it was pumping 6 to 10 barrels of heavy oil with 100 to 200 barrels of water.

VI. *Wells at Enterprise in Warren County.*

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130. *Benedict Estate Well, No.* 1. (167)

Summer of 1865.

Benedict Estate Farm, Enterprise, Warren Co. Authority, ———.

Well mouth above ocean in feet				1235
?	192	to	192	= 1043
1st S. S.	50	"	242	= 993
?	58	"	300	= 935
2d S. S.	6	"	306	= 929
?	29	"	335	= 900
3d S. S.	10	"	345	= 890
?	97	"	442	= 793
4th S. S.	6	"	448	= 787
?	14	"	462	= 773
5th S. S. pebble.	15	"	477	= 758
? pocket.	10	"	487	= 748

Wet hole. Cased at 342′. Pumped 10′ from bottom.

Best production 8 barrels per day. Half enough gas to fire 1 boiler. Green oil. Gravity 47°.

131. *McKinney Well, No.* 1. (170)

March, 1869.

Lease No. 9, Benedict Estate Farm, Enterprise, Warren County. Authority, C. B. McKinney.

Well mouth above ocean in feet	1222

? ..... estimated.	183	to	183	=	1039
1st S. S.	50	"	233	=	989
?	79	"	312	=	910
2d S. S.	10	"	322	=	900
?	88	"	410	=	812
3d S. S.	20	"	430	=	792
?	10	"	440	=	782
4th S. S. ..... pebble.	16	"	456	=	766
? ..... pocket.	18	"	474	=	748

Wet hole. Cased at 338′.

Best production 180 barrels per day. Gas sufficient to fire 2 boilers. Green oil. Gravity 45°.

The 4th S. S. is the oil bearing rock. The 2d S. S. contains large veins of salt water. The well has been run one month and is as good as ever on an average.

132. *McKinney Well, No. 2.* (171)

August, 1868.

Lease 17, Benedict Estate, Enterprise, Warren County. Authority, C. B. McKinney.

Well mouth above ocean in feet 1225

? ..... estimated.	196	to	196	=	1029
1st S. S.	60	"	256	=	969
?	58	"	314	=	911
2d S. S. ..... pebble.	14	"	328	=	897
?	86	"	414	=	811
3d S. S.	20	"	434	=	791
?	10	"	444	=	781
4th S. S. ..... pebble.	21	"	465	=	760
? ..... pocket.	17	"	482	=	743

Wet hole. Cased at 335′. Pumped 6′ from bottom.

Best production 30 barrels per day. Gas sufficient to fire one boiler. Green oil. Gravity 45°.

A torpedo improves the well. 2d S. S. contains salt water. 4th S. S. is oil producing.

VII. *Wells at Church Run and in its Vicinity, in Crawford County.*

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133. *Eureka Well.* (202)

November 1865.

On land of Atlantic and Great Western Petroleum Co., on Church Run, one and a-half miles north-east of Titusville, Crawford County. Authority, H. S. Rogers, Superintendent.

Well mouth above ocean in feet 1327

?		230	to	230	= 1097
1st S. S.		67	"	297	= 1030
?		174	"	471	= 856
2d S. S.		15	"	486	= 841
?		18	"	504	= 823
3d S. S.	very coarse with pebbles.	70	"	574	= 753
?	pocket.	10	"	584	= 743

Wet hole. Cased at 350′. Pumped 15′ from bottom.

Best production 175 barrels per day. Gas sufficient to fire 3 boilers. Green oil. Mud veins are found in some of the wells on the higher ground, but were rare in the Eureka well.

This well from the long time that it has been pumping can be considered to be one of the most remarkable in this region, having been one of the first drilled on Church Run. It now averages 140 barrels per week [February, 1869].

When first started it produced about 52 barrels per day. It gradually ran down until in May (1868), it was producing about 25 barrels per week. It was then cleaned out, casing and seed-bag being drawn, and torpedoed in the middle of the third sand. Casing was then put in, and it was started up, and for some days produced 175 barrels per day. Referring to the books, I find that in one week it pumped 910 barrels of the best, clear Church Run oil.

We find that a torpedo, every six weeks, is required to be exploded in the middle of the third sand, to open up and clean the rock. There is still sufficient gas to run the engine [February, 1869].

The company are now pumping their eleventh well. Out of this number but two have proved failures.

134. *Niagara Well, No.* 1. (201)

May, 1867.

On three acre tract, formerly Cadwallader and Morse at Church Run, Crawford Co. Authority, ———.

Well mouth above ocean in feet					1312
?		218	to	218	= 1094
1st S. S.		40	"	258	= 1054
?		200	"	458	= 854
2d S. S.		15	"	473	= 839
?		16	"	489	= 823
3d S. S.	pebble and sand.	65	"	554	= 758
?	pocket.	9	"	563	= 749

Wet hole. Cased at 300′. Pumped 13′ from bottom.

Best production 25 barrels per day. Gas sufficient to fire 1 boiler. Green oil. Gravity 45°.

135. *"Ike" Weed Well.* (204)

January, 1867.

On tract of Williams, Severance and Co., on Church Run, one and a quarter mile north-east of Titusville, Crawford Co. Authority, L. H. Severance, Treas.

Well mouth above ocean in feet				1394
?	298	to	298	= 1096
1st S. S.	30	"	328	= 1066
?	209	"	537	= 857
2d S. S.	15	"	552	= 842
?	19	"	571	= 823
3d S. S. ....pebble.	66	"	637	= 757
? ....pocket.	9	"	646	= 748

Wet hole. Cased at 400′. Pumped 35′ from bottom.

Best production 15 barrels per day. Oil green. Gravity 47°. Gas sufficient to fire 1 boiler.

Well is now [February 12th, 1869] pumping on an average 6 barrels per day. Are only running it in the day, making but 12 hours pumping. With torpedoes, has pumped 10 barrels per day.

136. *Humphrey Well, No.* 2. (205)

December, 1868.

On Atlantic and Great Western Petroleum Co.'s tract on Church Run, one and one-half miles north-east of Titusville, Crawford Co. Authority, —.

Well mouth above ocean in feet				1425
?	330	to	330	= 1095
1st S. S.	60	"	390	= 1035
?	175	"	565	= 860
2d S. S.	25	"	590	= 835
?	20	"	610	= 815
3d S. S. ....sand and pebble.	62	"	672	= 753
? ....pocket.	3	"	675	= 750

Wet hole. Cased at 404′. Pumped 14′ from bottom.

Best production, 300 barrels per day. Green oil. Gravity 45°. Gas sufficient to fire 3 boilers.

This well is now [February 9th, 1869] pumping 65 barrels per day.

137. *Yreka Well, No.* 1. (206)

August, 1868.

On the Weed Farm, Church Run, $1\frac{1}{4}$ miles north-east of Titusville, Crawford Co. Authority, Chester Morse.

Well mouth above ocean in feet				1454
?	365	to	365	= 1089

1st S. S.		63	to	428	= 1026
? including 2d S. S		212	"	640	= 814
3d S. S.	sand and pebble.	60	"	700	= 754

Wet hole. Cased at 365′.

Best production 70 barrels per day. Gas sufficient to fire 2½ boilers. Green oil. Gravity 45°.

138. *King Well.* (211)

1864.

On Watson Flats, ½ mile south of Titusville, Crawford Co. Authority,——.

Well mouth above ocean in feet					1168
?		170	to	170	= 998
1st S. S.		20	"	190	= 978
?		190	"	380	= 788
2d S. S.		35′	"	415	= 753

Wet hole. Cased at 180′. Pumped 10′ from bottom.

Best production 10 barrels per day. Green oil. Gravity 44°. One half enough gas to fire a boiler.

This well has been pumped nearly all the time since it was struck, while in the immediate vicinity many have been abandoned and left without any seed-bag. It is the opinion of many, that if three-fourths of the holes on the flat were seed bagged the other fourth would be paying wells at the present time [about Jan., 1869].

VIII. *Miscellaneous Wells.*

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139. *Major Well.* (279)

Summer of 1867.

On Major Farm, section 1618, Sparta Township, 2½ miles S. E. of Spartansburg, Crawford Co. Authority, Wm. Johns.

Well mouth above ocean in feet					1600
?		205	to	205	= 1395
1st S. S.		15	"	220	= 1380
?		240	"	460	= 1140
2d S. S.	white, coarse.	25	"	485	= 1115
?		260	"	745	= 855

Wet hole. Seed-bagged on tubing at 210′. Gas sufficient to fire 15 boilers. No oil

This well was tested by pumping it for one day, when it gave signs of flowing. The second day the rods and valves were drawn, when it commenced flowing gas and water at the rate of about 100 barrels per day, and continued thus for six months. The tubing was then drawn to explode a

torpedo. It was afterwards tubed, and flowed water for 9 months, when the seed-bag burst. Since then nothing has been done to it. At one time the water flowed outside of the tubing, and was thrown 15 feet high.

140. *Well No.* 175. (301)

Triumph Oil Company, Triumph, Warren Co., 2 miles south-west of Tidioute. Authority, Superintendent of Farm.

Well mouth above ocean in feet				1685
?	224	to	224	= 1461
1st S. S.	28	"	252	= 1433
?	205	"	457	= 1228
2d S. S.	18	"	475	= 1210
?	85	"	560	= 1125
3d S. S.	22	"	582	= 1103
?	120	"	702	= 983
4th S. S. not through it.	40	"	742	= 943

No well on this farm has drilled through the 4th sand though some have gone 80′ into it. No oil is obtained below 10 to 20 feet from the top of the rock. At the present time this well is being drilled deeper into the sand.

Most of the wells in Dennis Run use gas pumps. [Nov. 4th, 1869.]

141. *Jocelyn Well, No.* 1. (294)

April 14, 1866.

Located on lease No. 1, plot 7, section C of the Jocelyn Oil Lands (old Green Farm), 4½ miles south-east of Pleasantville, and 3 miles south of Neilltown, Forest Co. Authority, A. H. Jocelyn, Vice-President.

Well mouth above ocean in feet				1597
?	112	to	112	= 1485
1st Mt. S. S.	50	"	162	= 1435
?	150	"	312	= 1285
2d Mt. S. S.	25	"	337	= 1260
?	243	"	580	= 1017
1st Oil S. S.	78	"	658	= 939
?	27	"	685	= 912
2d S. S.	25	"	710	= 887
?	70	"	780	= 817
3d S. S.	45	"	825	= 772
?	17	"	842	= 755
4th Extra S. S. white pebble.	15	"	857	= 740
?	143	"	1000	= 500

Wet hole. Not cased. Pumped at 800′ from top.

Best production 1 barrel per day. Little gas. Black oil. Gravity 40° and 47°. Mud vein 790′ to 798′.

"Owing to accident, losing tools in this well, and fishing for them several weeks in a stiff mud vein at top of the pebble rock, the well was spoiled. She was afterwards drilled to 1000′ as an experiment, to ascertain the fullest extent of Geology, but found nothing of importance below 857′, and the full regular oil-bearing rocks ending at 857′. It is my opinion, after careful study and practical knowledge, that this land is equal to the best oil territory, and with further developments will prove an extended oil field. This geology differs from all below on Stewart's Run."

The foregoing records are published to secure them against accidental loss by fire or otherwise, and to place them in a convenient form for reference. Many of them are imperfect, and some, without doubt, do not correctly represent the stratification of the rocks drilled through; still they are of great value, and when the whole series is completed there will be a sufficient number of approximately reliable ones to exhibit in a very satisfactory manner the general underground structure to any one who will take the trouble to study it out. Their value will be more apparent years hence than it is now, when the old districts are again worked over, as they undoubtedly will be, and the early records are not otherwise to be obtained. During the first development of a district, when scores of wells are in operation, almost every well owner or employé has a knowledge of the rocks sufficient for all practical purposes; but when the district has become partially exhausted, and the original operators have moved forward to other fields, leaving new men behind who know very little of the history of the wells, then these printed records will be sought after and appreciated.

If this plan of preserving records had been adopted when oil was first discovered and followed up to the present time what a vast amount of valuable material would now be accessible to all. Thousands of faithfully kept registers have been made. Some were merely written in a convenient place on the derrick or engine house and perished with the well; some were kept in daily hand-books which were discarded and destroyed as they became old; many have been consumed by fire, that inevitable visitant of all our oil towns; and others are now stowed away among the oil region relics of those who have left the country, and scattered almost to the four corners of the earth. Scarcely one in a hundred of them can now be found.

Those who have well records in their possession can now have them published and preserved with the papers of the survey by mailing them to the headquarters of the Oil District at Pleasantville, Pennsylvania. They will be printed in pamphlet form from time to time as they accumulate in sufficient numbers, for free distribution to those who have contributed them.

In examining these records it will be observed that the first column of figures gives the thickness of each sand-rock or interval; the second, the depth from the surface to both the top and bottom of each sand rock or interval; and the third, the elevation above ocean (where it is known), so that it can be seen at a glance, without any calculation, just what the thickness of each formation is, how far it lies below the surface, and how high above the ocean. This form of keeping records if universally adopted will be found to greatly facilitate their comparison and study.

On Centres of Aggregation and Dissociation.

By Pliny Earle Chase, LL.D., Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, Jan. 5, and Feb. 2, 1877.*)

I. *Æthereal Influences in the Solar System.*

The velocity of rotation varies as the square root of the velocity of gravitating fall. Therefore, if the velocity of planetary revolution ($\sqrt{gr}$) at Sun's equatorial surface be taken to represent the velocity of æthereal rotation at the same point, the present æthereal atmospheric limit, at which the equatorial velocity of rotation would be equal to that of the æthereal undulations which drive particles towards centres of inertia, is near the outer limit of the asteroidal belt, at ($\sqrt{\text{Light-Modulus}}$ = 688.3 solar radii = 3.204 Earth's mean vector-radii). The mean proportional between Earth's mean distance and Saturn's* secular aphelion is 3.216.....(1.)

We have found that the velocity at the æthereal atmospheric limit (the velocity of light), is the limiting mean radial velocity, at the point of equilibrium between the velocity of complete dissociation and the velocity of incipient aggregation. The limiting tangential velocity, at the point of equilibrium between complete aggregation and incipient dissociation, is, therefore,† $\frac{1}{\pi}$ of the velocity of light, which is the velocity of æthereal rotation at 219.09 solar radii, Earth's mean distance being 214.86.....(2.)

We have also found‡ that Jupiter, the largest extra-asteroidal, and Earth, the largest intra-asteroidal planet, are connected by a common limiting radial velocity, the indications pointing to nucleal or rotating influences in the case of Earth, and to atmospheric or orbital influences in the case of Jupiter. Circular-orbital velocity varies as $g^{\frac{1}{4}}$. The relations of g to $\sqrt{M}$ (1) and of Earth's position to the unit of solar aggregation (2), lend importance to the approximate equality between log. $(\sqrt{M})^{\frac{1}{4}}$ = .709444 and log. rad. vec. ($\mathcal{U} : \oplus$) = .716237.....(3.)

Alexander showed§ that Jupiter and Saturn are so related as to suggest a possible early mutual participation in a common nucleal *vis viva*; as if they had been formed, by interior and exterior condensation, from the same nebulous belt. I have shown‖ that the atmospheric radius varies as the $\frac{1}{3}$ power of the nucleal radius. Therefore, if $M^{\frac{1}{3}}$ represents Jupiter's posi-

*"Fundamental Propositions of Central Force," (*ante*, p. 293–310) VI.

†Ib., V.

‡Ib., V—VII, Illustrations.

§Smithsonian Contrib., 280, p. 38.

‖"Fundamental Propositions," X.

tion(3) at the extremity of a nucleal radius, the corresponding atmospheric radius $= (\sqrt[8]{\mathrm{M}})^{\frac{4}{3}} = \mathrm{M}^{\frac{1}{6}}$, of which the logarithm is .945926. The log. of ♄ secular perihelion ÷ ⊕ mean radius vector is .941236.....(4.)

The secular perihelion of Venus is near the æthereal nucleal limit (1, 4). Log. $(\sqrt{\mathrm{M}})^{\frac{3}{4}} = 2\ 128332$, log. ♀ sec. perihelion being 2.159680. 2.159680 — 2.128332 = .031348 = log. 1.07483. ♀ secular aphelion ÷ mean r. vec. = 1.07633.....(5.)

These approximations point to æthereal influences on the principal planets, both in the supra- and in the infra-asteroidal belts, and to early special nucleal condensation in the inner belt. The latter indication is strengthened by the greater density of the interior planets, by the many harmonic relations which are based on Earth's distance as a primitive unit, and by Earth's position near the centre of the infra-asteroidal belt. Mercury's secular perihelion (.29743) + Mars's secular aphelion (1.73633) = 2.03376; 2.03376 ÷ 2 = 1.01688. Earth's present aphelion = 1.01678.....(6.)

The nucleal-atmospheric relations of Earth and Jupiter (3) are further shown by the fact that a nucleal expansion of Sun to Earth's secular perihelion (200.307 solar radii) would involve an atmospheric expansion to $(200.307^{\frac{4}{3}} = 1172)$. Jupiter's mean aphelion = 1166.61 solar radii....(7.)

The present Light-Modulus (log. M ÷ ⊙r = 5.675554) : Earth's accelerative radius (log. $2\rho^2 = 4.965340$) : : Jupiter's secular aphelion (log. = .741881) : Earth's secular aphelion (log. = .028463).....(8.)

Earth's rotating, relatively to its orbital velocity, has been accelerated 366.256 times, since its theoretical nebular rupture. This represents the ratio of Earth's nucleal-rupturing to Sun's aggregating radius (2). For if we let ρ = superficial radius and velocity of perfect fluidity in the æthereal nucleus (1), $\rho\sqrt{2}$ = radius of dissociating velocity, and $2\rho^2$ = radius of rupturing *vis viva*. Log. (ρ = ⊕ secular perihelion) = 2.301695. Log. ($2\rho^2$ ÷ 219.0894) = 2.563791 = log. 366.253.....(9.)

The increased acceleration of Jupiter's angular velocity, relatively to its nucleal companion Earth, is such as would be due to the difference of orbital velocities at the outer and inner edges of the Jovi-Telluric belt. Log. ♃ secular aphelion (.741881) — log. ⊕ sec. perihelion ($\bar{1}$.969540) = log. 2.433^2. 24 hours ÷ 2.433 = 9 h. 51 m. 49 s.....(10.)

Jupiter's rotating, relatively to its orbital velocity, has been accelerated in the ratio of its mean rupturing radius to Sun's aggregating radius. For log. (ρ = ♃ mean perihelion) = 3.029231; log. ($2\rho^2$ ÷ 219.0894) = 4.018865 = log. 10443.97; 4332.585 dy. ÷ 10443.97 = 9 h. 57 m. 22 s. See (7) 35) (48).....(11.)

Saturn's rotating, relatively to Jupiter's orbital velocity, has been accelerated in the ratio of Jupiter's nucleal rupturing to Sun's aggregating radius. For log. (= ♃ sec. per.) = 3.021137; log. ($2\rho^2$ ÷ 219.0894) = 4.022677 = log. 10061.83; 4332.585 dy. ÷ 10061.83 = 10 h. 20 m. 3 s.....(12.)

Saturn's rotating, relatively to its orbital velocity, has been accelerated

in the ratio of its initial-rupturing radius to Earth's radius of rupture. For log. (ρ = ♄ sec. aph.) = 3.346812 ; log. ($2\rho^2 \div 200.307$) = 4.391929 = log. 24656.36 ; 19759.22 dy. ÷ 24656.36 = 10 h. 14 m. 4 s .....(13.)

The rotating velocity of Mars, relatively to its orbital velocity, has been accelerated nearly in the ratio of its nucleal-rupturing radius to Earth's secular aphelion. For log. (ρ = ♂ sec. per.) = 2.449775 ; log. ($2\rho^2 \div 229.413$) = 2.839962 = log. 691.77 ; 686.98 dy. ÷ 691.77 = 23 h. 49 m. 49 s. .....(14.)

The rotating velocity of Venus, relatively to its orbital velocity, has been accelerated in the ratio of its mean rupturing radius to Earth's mean perihelion. For log. ρ = 2.191493 ; log. ($2\rho^2 \div 207.583$) = 2.366824 = log. 232.715 ; 224.7 dy. ÷ 232.715 = 23 h. 13 m. 36 s.....(15.)

The rotating velocity of Mercury, relatively to its orbital velocity, has been accelerated in the ratio of its initial-rupturing radius to Sun's aggregating radius. For log. (ρ = ☿ sec. aph.) = 1.990608 ; log. ($2\rho^2 \div 219.0894$) = 1.941619 = log. 87.422 ; 87.97 dy. ÷ 87.422 = 24 h. 9 m. 2 s. .....(16.)

Jupiter's secular aphelion (5.5193) is a mean proportional between Earth's mean distance, and Neptune's secular aphelion (30.4696). See also, *infra* (27) to (29).....(17.)

The secular perihelion of Uranus, or its locus of nebular rupture (17.688), is at the centre of the supra-asteroidal belt. For Neptune's secular aphelion (30.470) + Jupiter's secular perihelion (4.886) = 35.356 ; 35.356 ÷ 2 = 17.678.....(18.)

The secular perihelion of Uranus is also a mean proportional between Saturn's secular aphelion (10.343) and Neptune's mean aphelion (30.336).....(19.)

The centres of the outer and inner planetary belts are so related that the mean distances of Uranus (19.184) and Earth's secular perihelion (.932), are at apses of a major-axis which would be traversed by light undulations in the time of planetary revolution at Sun's surface. (19.184 + .932 = 20.116 ; 688.3 × 2π ÷ 214.86 = 20.128) .....(20.)

The major-axis of the November meteoric orbit is also nearly equivalent to the major-axis of these primeval light undulations. For the meteoric period = 33.25 yr.; $2 \times 33.25^{\frac{2}{3}} = 20.68$.....(21.)

When Sun's surface of dissociation was at the extremity of Earth's mean radius vector, the locus of complete association, or the vertex of the stellar-solar paraboloid*, was at Mercury's present perihelion (.3187). $1 \div \pi =$ .3184.....(22.)

The orbital velocity varies (3) as the one-fourth power of the gravitating velocity. The orbital velocity at the mean aphelion of the intra-asteroidal belt, is equivalent to the mean velocity of the centripetal gravitating im-

* Ib. X, Illustrations. By an inadvertence it was stated that there are nine abscissas between Neptune and *a* Centauri. There were nine in my original paraboloid (Proc. S. P. A., Sept. 20, 1872), but if the vertex is taken at the locus of complete solar aggregation there are eighteen.

pulses beyond the belt. For log. (sec. aph. ♆ × sec. aph. ♂)$^{\frac{1}{8}}$ = .215437; log. mean aph. ♂ = .215944.....(23.)

The mean velocity of the centripetal gravitating impulses in the principal nucleal belt is equivalent to the same orbital velocity. For log. (sec. aph. ♄ × mean ☿)$^{\frac{1}{8}}$ = .216362.....(24.)

There is, therefore, an equivalence between the mean exterior and the mean nucleal gravitating impulses, beyond the Telluric belt. For log. (sec. per. ♆ × sec. aph. ♂)$^{\frac{1}{2}}$ = .855866; log. (sec. aph. ♄ × mean per. ☿)$^{\frac{1}{2}}$ = .855450.....(25.)

The orbital velocity varies as the one-half power of the rotating velocity. The mean orbital velocity due to nebular action in the Neptuno-Uranian belt, is equivalent to the rotating velocity at the locus of nebular rupture in the principal nucleal belt. For log. (mean per. ♆ × mean ☉)$^{\frac{1}{4}}$ = .689039; log. sec. per. ☿ = .688982.....(26.)

The initial rupturing position of the centre of planetary mass (17) is determined by the mean influence of the intra-asteroidal centres (6), the supra-asteroidal centre (18), and the nebular centre of planetary inertia (♄). For log. (mean ⊕ × sec. per. ☉ × mean ♄)$^{\frac{1}{3}}$ = .742338; log. sec. per. ☿ = .741881.....(27.)

The same position is also a mean proportional between the centre of the supra-asteroidal and the outer limit of the intra-asteroidal belt. For log. (sec. per. ☉ × sec. aph. ♂)$^{\frac{1}{2}}$ = .743575.....(28.)

The nebula-rupturing position of the centre of planetary mass is at the centre of the initial planetary system. For sec. aph. ♆ (30.470) — sec. aph. ♃ (20.679) = 2 × sec. per. ☿ (4.886).....(29.)

The initial position of mean planetary inertia is determined by the mean positions of the rupturing loci of the two principal two-planet belts. For log. (☉ × ☿)$^{\frac{1}{2}}$ = .999583; log. mean aph. ♄ = 1.000003.....(30.)

The atmospheric limit (4) of the infra-asteroidal belt, is determined by positions of Sun, Jupiter, and Neptune. For log. $\overline{(☿ \times ♆)^{\frac{1}{2}} \div \odot r}$ = 3.429079; log. (sec. aph. ♂ ÷ ⊙ r)$^{\frac{4}{3}}$ = 3.429048.....(31.)

The atmospheric limit of the initial position of the infra-asteroidal centre, is determined by positions of Sun, Jupiter, and Saturn. For log. $\overline{(\text{sec. per. } ☿ \times \text{sec. per. } ♄)^{\frac{1}{2}} \div \odot r}$ = 3.147264; log. (sec. aph. ⊕ ÷ ⊙ r)$^{\frac{4}{3}}$ = 3.147491.....(32.)

The atmospheric limit of the initial tendency to infra-asteroidal rupture, is determined by positions of Sun, Jupiter, and Earth. For log. $\overline{(\text{mean per. } ☿ \times ⊕)^{\frac{1}{2}} \div \odot r}$ = 2.680693; log. (sec. aph. ☿ ÷ ⊙r)$^{\frac{4}{3}}$ = 2.680615.....(33.)

The atmospheric limit at the inner locus of infra-asteroidal rupture, is

the nucleal rupturing limit, relatively to Earth, of Mars. For log. (sec. per. ☿ ÷ ⊙r)$^{\frac{4}{3}}$ = 2.420721 = log. 1 226 ⊕r.vec.; (sec. per. ♂ ÷ ⊕)$^{\frac{3}{4}}$ = 1.225.....(34.)

The atmospheric limit at the central locus of infra-asteroidal rupture, is at Jupiter's mean aphelion. For log. (sec. per. ⊕ ÷ ⊙r)$^{\frac{4}{3}}$ = 3.068927; log. (mean aph. ♃ ÷ ⊙r) = 3.066743..... 35.)

The atmospheric limit at the rupturing locus of Mars, is near the rupturing limit of Saturn. For log. (sec. per. ♂ ÷ ⊙r)$^{\frac{4}{3}}$ ÷ ⊕r.vec. = .934212; log. sec. per. ♄ = .941236; .941236 — .934212 = .007024 = log. 1.0163. This indicates a similarity of contraction at the centre (6) and at the outer limit of the belt.....(36.)

The atmospheric limits of the Venus belt, as determined by reference to the rupturing position of Mercury, are in or near the Earth belt. For log. (♀ ÷ sec. per. ☿)$^{\frac{4}{3}}$ ÷ ⊕r. vec. = $\bar{1}$.942238 @ .024175; log. ⊕ = $\bar{1}$.969540 @ .028463.....37.)

The atmospheric limits of the Earth belt, referred to the rupturing position of Mercury, are within the Mars belt. For log. (⊕ ÷ sec. per. ☿)$^{\frac{4}{3}}$ = .131591 @ .210155; log. ♂ = .117620 @ .239631.....(38.)

The atmospheric limits of the Mars belt, referred to the rupturing position of Mercury, are within the asteroidal belt.....(39.)

The atmospheric limit at Venus's mean aphelion, referred to Mercury's mean locus, is at Earth's rupturing locus. For log. (mean aph. ♀ ÷ ☿)$^{\frac{4}{3}}$ = .382120; log. (sec. per. ⊕ ÷ ☿) = .381719.....(40.)

The atmospheric limit at Earth's initial locus, referred to the initial locus of Mercury, is at the mean perihelion of Mars. For log. (sec. aph. ⊕ ÷ sec. aph. ☿)$^{\frac{4}{3}}$ = .466876; log. (mean per ♂ ÷ sec. aph. ☿) = .468819.....(41.)

The initial locus of Earth is at the mean aphelion thermal radius of Venus. For log. 1.4232 (mean aph. ♀ ÷ ⊕) = .027677; log sec. aph. ⊕ = .028463.....(42.)

The atmospheric limit at the rupturing locus of Mars (36), referred to the rupturing position of Venus, is near the mean aphelion of Mars. For log. (sec. per. ♂ ÷ sec. per. ♀)$^{\frac{4}{3}}$ = .214318; log. mean aph. ♂ = .215944.....(43.)

The inner atmospheric limit of the Jupiter belt, referred to the rupturing position of Venus, is at Saturn's mean distance. For log. (sec. per. ♃ ÷ sec. per. ♀)$^{\frac{4}{3}}$ = .976134; log. ♄ = .979496.....(44.)

The outer atmospheric or initial limit of the Jupiter belt, referred to the rupturing position of Venus, is near Saturn's initial locus. For log. (sec. aph. ♃ ÷ sec. per. ♀)$^{\frac{4}{3}}$ = 1.046666; log. sec. aph. ♄ = 1.014657; 1.046666 :- 1.014657 = .032009 = log. 1.077 = log. (sec. aph. ÷ mean ♃). See (3) to (5), (20).....(45.)

The inner atmospheric limit of the Saturn belt, referred to the rupturing limit of Venus, is at the secular aphelion of Uranus. For log. (sec. per ♄ ÷ sec. per. ♀)$^{\frac{4}{3}}$ = 1.312473 ; log. sec. aph. ♅ = 1.315531.....(46.)

The outer atmospheric limit of the Saturn belt, referred to the rupturing position of Mars, is also at the secular aphelion of Uranus. For log. (sec. aph. ♄ ÷ sec. per. ♂)$^{\frac{4}{3}}$ = 1.313669.....(47.)

The inner atmospheric limit of the Jupiter belt, referred to Earth's rupturing position, is near Saturn's rupturing position. For log. (sec. per. ♃ ÷ sec. per. ⊕)$^{\frac{4}{3}}$ = .928796 ; log. sec. per ♄ = .941236 ; .941236 — .928796 = log 1.029. ..... (48.)

The outer atmospheric limit of the Jupiter belt, referred to Earth's rupturing position, is at the mean aphelion of Saturn. For log. (sec. aph. ♃ ÷ sec. per. ⊕)$^{\frac{4}{3}}$ = .999328 ; log. mean aph. ♄ = 1.000003.....(49.)

The mean atmospheric limit of the Saturn belt, referred to Earth's mean position, is near the mean aphelion of Uranus. For log. (♄ ÷ ⊕)$^{\frac{4}{3}}$ = 1.305995 ; log. mean aph. ♅ = 1.301989.....(50.)

The atmospheric limit at Jupiter's mean aphelion, referred to the rupturing position of Mars, is at Saturn's rupturing position. For log. (mean aph. ♃ ÷ sec. per. ♂)$^{\frac{4}{3}}$ = .940244 ; log. sec. per ♄ = .941236.....(51.)

The mean atmospheric limit of the Uranus belt, referred to Jupiter's rupturing position, is at Neptune's mean aphelion. For log. (♅ ÷ sec. per. ♃)$^{\frac{4}{3}}$ = 1.480913 ; log. mean aph. ♆ = 1.481951.....(52.)

The same limit (52), referred to Jupiter's mean perihelion, is at Neptune's mean locus. For log. (♅ ÷ mean per. ♃)$^{\frac{4}{3}}$ = 1.478215 ; log. ♆ = 1.477611.....(53.)

The same limit, referred to Jupiter's mean position, is at Neptune's rupturing position. For log. (♅ ÷ ♃)$^{\frac{4}{3}}$ = 1.471828 ; log. sec. per. ♆ = 1.471268.....(54.)

The important influence of Earth's position at a centre of early nucleal condensation, is also shown by the simplicity of relations between Earth's radius vector and the secular epicyclical undulations of the supra-asteroidal planets.

Earth and Sun are convertible points of suspension, for a linear pendulum equivalent to the secular excursion of Uranus. For 3 ÷ 38.365 = .0782 ; the maximum eccentricity of Uranus is .0789 ; see (20) (21).....(55.)

The excursion of Saturn is nearly equivalent to the atmospheric limit of a nucleus which has Earth's thermal radius ($1.4232^{\frac{4}{3}}$ = 1.601). For 1.601 ÷ 19.078 = .0839 ; the maxium eccentricity of Saturn is .0843.....(56.)

The excursion of Jupiter is equivalent to the mean radius of rotating inertia at Earth's mean distance ($\sqrt{.4}$ = .6325). For .6325 ÷ 10.406 = .06078 ; the maximum eccentricity of Jupiter is .06083.....(57.)

The excursion of Neptune is in the inverse ratio of its own coefficient

($\frac{8}{9}$) and in the direct ratio of the coefficient of Uranus ($\frac{7}{8}$), in the abscissas of the stellar-solar paraboloid which has its vertex at the point of complete solar aggregation.* For $\frac{7}{8} \div 60.074 = .0147$, the maximum eccentricity of Neptune is .0145. ....(58.)

The following table shows the closeness of approximation (Theoretical less Observed ÷ Observed), in each of the foregoing comparisons :

1 —.0039	15 .0052†	30 —.0010	45 —.0009
2 .0197	16 —.0028†	31 .0001	46 —.0070
3 —.0158	17 .0001	32 —.0005	47 —.0043
4 .0109	18 —.0006	33 .0002	48 .0291
5 —.0014	19 .0019	34 .0008	49 —.0016
6 .0001	20 .0006	35 .0050	50 .0093
7 .0033	21 —.0224	36 .0006	51 —.0023
8 .0074	22 —.0013	37 .0000	52 —.0025
9 .0000	23 —.0012	38 .0000	53 —.0014
10 .0070†	24 .0010	39 .0000	54 —.0013
11 —.0023†	25 .0010	40 .0009	55 .0030
12 .0169†	26 .0001	41 —.0045	56 —.0050
13 .0238†	27 .0011	42 —.0018	57 —.0008
14 .0319†	28 .0039	43 —.0038	58 .0014
	29 .0019	44 —.0078	

One of the most important corollaries of the theory of universal gravitation, is tersely stated by Stockwell,‡ as follows : "The amount by which the elements of any planet may ultimately deviate from their mean values can only be determined by the simultaneous integration of the differential equations of these elements, which is equivalent to the summation of all the infinitesimal variations arising from the disturbing force of all the planets of the system during the lapse of an infinite period of time." Therefore, within the limits of secular eccentricity, the result is the same *as if* the nebular hypothesis were true.

There should, then, be tendencies, in the neighborhood of every inert particle which floats in an elastic medium, to the formation of harmonic nodes of various kinds, and the sum of such tendencies should fix loci of cosmical aggregation before there had been any considerable shapings of definite mass. The subsequent values of relative mass would depend upon mutual conditions of equilibrium between various forms of living force.

But such accordances as the foregoing, however interesting, and however striking they might be deemed, would furnish no more conclusive evidence of the nebular theory, as popularly interpreted, than of the Cartesian vortices. All assumptions as to the nature of ultimate physical force, are now, and perhaps always will be, mere assumptions ; still, like geometrical diagrams, they may help to fix the mind upon ultimate physical resultants, and thus serve a useful purpose.

* Ib. † According to Herschel's estimate.

‡Smithsonian Contributions, 232. viii.

Stockwell also remarks* that "a comparison of the values which the different solutions give for the superior limit of the eccentricity of the Earth's orbit, has suggested the inquiry whether there may not be some unknown physical relation between the masses and mean distances of the different planets." If such a relation exists, the constancy of the mean distances would also seem to imply a like constancy of absolute or relative masses, and the inquiry naturally arises, which is the logical antecedent; whether distance has determined mass or mass has determined distance.

There is abundant evidence on the one hand, of "cosmical dust," and meteorites, which are contributing to the enlargement of the sun and the planets; on the other, of internal convulsions, which are occasionally ejecting materials beyond the reach of primitive attraction. It is commonly believed that the enlarging tendencies predominate, and that the sum of all physical tendencies is towards stagnation, death, and universal gloom. Such a belief seems to me erroneous, and based upon limited considerations. It is not easy, as yet, to trace all the compensative and restorative energies, but some of them are strongly indicated by the various cosmical relations which, through all periodic and secular inequalities, tend to maintain the stability of planetary orbits.

In judging of the probable logical antecedence, it is well to remember, that all of the correlations which I have pointed out have been based upon general considerations of oscillatory centres, as influenced by radial, tangential, superficial, and volumetric disturbances, with reference to simple centres of inertia, and entirely independent of mass. My own convictions that spirit must necessarily, both logically and chronologically, take precedence of matter, have been strengthened by my investigations. Others, who have been accustomed to look more exclusively to physical influences, may perhaps be differently impressed by them. If they can give any physical explanation of the instantaneous action of gravity at all distances, or if they can frame any satisfactory hypothesis to account for such action except by constant spiritual activity, it will be gladly welcomed by all sincere seekers after truth. If, on the other hand, they admit that instantaneous action is incompatible with inertia, they may find that their own studies of nature lead them to a sure recognition of the supernatural, as an essential element of sound and catholic philosophy.

If a nebulous mass were to be divided by some internal convulsion, the ruptured portions would be projected from their common centre of gravity to distances varying inversely as their masses. If the first rupture were simple and one mass were much larger than the other, it could not obey the tendency to revolve about the common centre of gravity in a time proportional to the $\frac{3}{2}$ power of the distance, but the tendency might be manifested in other equivalent ways. The synchronism of linear oscillations through twice the diameter, and orbital oscillations through the circumference of a circle, points to a possible mode of such manifestation, by the removal of the larger mass to such distance as would allow the linear oscillations, or equivalent

*Op. cit., xvii.

tangential oscillations. This is the case with Sun and Jupiter. For if we represent the mass of Jupiter by 1, and Sun's mass by n, the secular perihelion distance of their centres, $.9391726 \times 5.2028 \times 214.86\, r = (n + 2)\, r$; and $n = 1047.876$. Bessel's value is 1047.879 .....(59.)

The atmospheric relation of Saturn to Jupiter (51) is further shown by the equality of nebular *vires vivæ*. For orbital *v. v.* $\propto \frac{m}{r}$; the nebulous mass at Jupiter's thermal radius vector,* is 1.4232^3, and the orbital *v. v.* at the corresponding atmospheric limit is $1.4232^3 \div 1.4232^{\frac{4}{3}} = 1.4232^{\frac{5}{3}} = 1.8007$, which is Alexander's ratio.† The *v. v.* of constrained rotation varies as the square of the orbital *v. v*, or, in the present case, as 3.2426 to 1, which would require masses in the ratio of 1 to 3.2426 to give equality of *v. v.*; provided the primitive orbits were circular. We have seen, however, (6), that the infra asteroidal centre is at $1.01688 \times$ Earth's mean distance, and the Jovi-Telluric connections (3) suggest the probability of a similar eccentricity in the primitive Jovi-Saturnian belt. $(1.4232^{\frac{5}{3}} \times 1.01688)^2 = 3.3525$; $1047.876 \times 3.3525 = 3513.47$. Bessel's ratio of Sun to Saturn is 3501.6; Le Verrier's 3512.....(60.)

Saturn's position at the nebular centre of planetary inertia would be likely to establish permanent records of equality in still other forms of *vis viva*. We accordingly find that the ratio of Neptune's to Saturn's mass seems to be due to nucleal *vis viva* (4) when they were both at atmospheric limits. For the *v. v.* of nucleal rotation varies as $\left(\frac{1}{d}\right)^{\frac{3}{2}}$; the $\frac{3}{2}$ power of Neptune's, divided by Saturn's mean distance, $= 5.587$; $5.587 \times 3513.47 = 19631$. Newcomb's ratio of Sun to Neptune, as deduced from the perturbations of Uranus is 19700.....(61.)

The mass ratio of Uranus to Saturn seems to be due to atmospheric *vis viva* when their nucleal condensation began. For the *v. v.* of rotation at the atmospheric limit varies as $\left(\frac{1}{d}\right)^{\frac{8}{3}}$; the $\frac{8}{3}$ power of mean distance ($\frac{2}{3} \div \frac{1}{5}$) is 6.444; $6.444 \times 3513.47 = 22641$; Newcomb's ratio of Sun to Uranus is 22600 ± 100.....(62.)

The mass ratio of Saturn to Earth seems to be due to equality of rotating *vis viva*. For the *v. v.* of rotation in a contracting nucleus varies as $\left(\frac{1}{d}\right)^2$; the square of mean distance ($\frac{1}{9} \div \frac{1}{1}$) is 90.99; $90.99 \times 3513.47 = 319690$. The ratio of Sun to Earth is still a mooted question.....(63.)

These theoretical masses are such as to contribute to the stability of the system, by giving equality between various forms of opposing *v. v.* at culminating points of opposing disturbance.

With the Sun expanded to Neptune's mean aphelion and rotating as a

* Fundamental Propositions, III, IV.

† Proc. S. P. A. xii. 394.

nebulous mass, at the beginning of interplanetary condensation (secular aphelion) the mean *vires vivæ* of the outer two-planet belts are equal. For the internucleal *v. v.* $\propto md^2$; log. md^2 ($\Psi \times \jupiter$) = 5.656948;* log. md^2 ($\saturn \times \mathcal{U}$) = 5.656817. See also (58).....(64.)

With Neptune at secular aphelion the mean *vires vivæ* of the outer and inner limits of the outer two-planet belts are equal. For under uniform æthereal resistance the *v. v.* is proportioned to the product of the mass by the trajectory, and the mean orbital trajectory is proportioned to the mean distance. Taking Uranus, Saturn and Jupiter at their mean distances, log md ($\Psi \times \saturn$) = 3.334505; log md ($\jupiter \times \saturn$) = 3.333751..(65.)

With Jupiter at Sun's nucleal surface, and the outer planets at tidal crests (secular aphelion), the mean *v. v.* of the two outer = mean *v. v.* of the two inner planets. For the *v. v.* of rotation in a shrinking nucleus $\propto m \div d^2$; the orbital *v. v.* $\propto m \div d$; log. ($\mathcal{U}$ *rot.* $\times$ Ψ *orb.*) *v. v.* = $\bar{2}$.480226; log. ($\jupiter \times \saturn$) *orb. v. v.* = $\bar{2}$.478969.. .....(66.)

In my equation of figurate powers, log. ($\Psi \times \jupiter^3 \times \mathcal{U}^6$) = 8.069488; log. $\saturn^{10}$ = 8.091570; log. $\saturn$ theoretical mass = .806949 .....(67.)

The internucleal *v. v.* ($\propto md^2$) of Saturn is equivalent to the mean internucleal *v. v.* of the supra-asteroidal belt. For if we consider Neptune at secular aphelion, Uranus and Saturn at mean distance, and Jupiter at secular perihelion, log. md^2 for Ψ = 3.029720; for $\jupiter$ = 2.565859; for $\saturn$ = 2.768149; for $\mathcal{U}$ = 2.712548; (3.029720 + 2.565859 + 2.768149 + 2.712548) $\div$ 4 = 2.769069 .....(68.)

The mean *v. v.* of æthereal rupturing projection (md) in the supra-asteroidal belt is equivalent to that of the Sun (59). For log. [mass ($\Psi \times \jupiter \times \saturn \times \mathcal{U}$) $\frac{1}{4} \div \odot \times$ secular perihelion $\Psi \div \odot$ radius] = $\frac{1}{4}$ ($\bar{5}$.707091 + $\bar{5}$.645107 + $\bar{4}$.454264 + $\bar{4}$.979691) + 3.803423 = $\bar{1}$.999961; log. mass $\odot \div \odot$ radius = .000000.....(69.)

Jupiter's mass is nearly equivalent to the mean mass of Sun, Earth and Saturn. For log. $\frac{1}{3}$ ($\odot \times \oplus \times \saturn$) = 1.338072; log. $\mathcal{U}$ = 1.334584...(70.)

II. *Chemical Atoms, Molecules and Volumes.*

In accordance with a suggestion of Professor Robert E. Rogers, I have endeavored to find what modes of central force will best represent some of the most general forms of chemical activity, more especially those which are the basis of the law of Avogadro and Ampére, of combination by volume, and of approximate constancy in the product of atomic weight by specific heat.

The simplicity of the ratio, between the energy of H_2O and the solar energy at Earth's mean distance,† furnishes good grounds for such an investigation, while the record of a parabolic orbit, connecting the Sun with the nearest fixed stars,‡ indicates a proper course for conducting it. Al-

* With Uranus as unit of mass, and Earth as unit of distance.

† *Ante* xii, 394; xiii, 142.

‡ *Ante*, xii, 523, and subsequent papers.

though there may be some doubt as to the degree of certainty which belongs to the recent hypotheses of internal gaseous structure, there can be none as to the graphic representation of orbital activities under forces varying inversely as the square of the distance. Circular orbits denote constancy of relations between radial and tangential forces; elliptic orbits, variability of relations accompanied by cyclical oscillations; parabolic orbits, variability of relations without cyclical oscillation; hyperbolic orbits, variability of relations complicated by the action of extraneous force.

In a rotating mass, the orbits of the several particles are circular. If the uniform velocity of any particle in the equatorial plane is less than $\sqrt{fr}$, the mean action of the central force is impeded by internal collisions or resistances. If the velocities of all the particles in the plane vary precisely as $\sqrt{fr}$, there is a condition of perfect fluidity, marking a limit between complete aggregation and incipient dissociation. Any cyclic variations of velocity between constant limits indicate elliptic orbits, with tendencies to aggregation through collisions near the perifocal apse. A perifocal velocity of $\sqrt{2fr}$ marks a parabolic orbit, and a limit between complete dissociation and incipient association. A velocity greater than $\sqrt{2fr}$ is hyperbolic, indicating the intervention of a third force in addition to the mutual action between the two principal centres of reference.

If all physical forces are propagated by æthereal undulations between resisting points, those points tend naturally to nodal, and from internodal positions. In order to maintain uniformity in the wave velocity, the æthereal molecules must be uniform, not only in volume, but also in aggregate inertia. As the inertia of the resisting points increases, the inertia due to internal æthereal motions, should, therefore, diminish, and *vice versâ*. In other words, the uniform elementary volume may be represented by the product of atomic weight by specific heat, and the laws of Boyle (or Mariotte), Charles, and Avogadro, follow as simple and necessary corollaries.

In order that uniform undulations should produce motion, there must be at least two points of resistance. Those points would approach each other until the interior undulating resistance equaled the exterior undulatory pressures, when their motion would be converted into rotation or into orbital revolution. Their common centre of revolution might become the centre of a new elementary volume, thus giving rise to the various laws of combination by volume, combination without condensation, condensation of two volumes into one, three volumes into two, or four volumes into two, as well as to general artiad and perissad quantivalence.

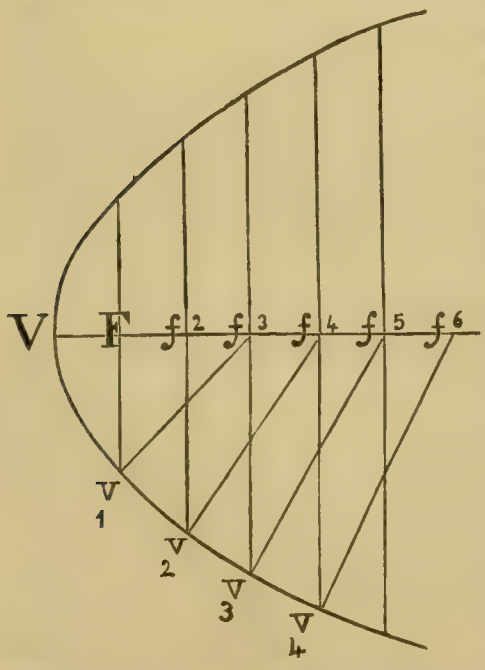
When perifocal collisions change parabolic or elliptic into circular orbits, there should be increasing density towards the principal centre of the system. Further collisions and condensations would produce tendencies to both nucleal and atmospheric* aggregations, and consequent binary groupings. These laws are exemplified in the solar system, by the general division into an intra asteroidal and an extra-asteroidal belt, and by the subdivis-

* *Ante*, xiv, 622, sqq.

ion of each belt into two pairs, the inner belt being denser than the outer, and the inner member of each pair being denser than its companion; Mercury being denser than Venus; Earth, than Mars; Jupiter, than Saturn; Uranus, than Neptune. This arrangement towards the Sun as a principal centre, appears, however, to be of more recent date than the tendency to condensation in the Telluric belt, for Earth is denser than Venus, and the great secular ellipticities of Mars and Mercury suggest the likelihood of a quasi-cometary origin. Similar tendencies would contribute to the chemical grouping of atoms by pairs, which is essential for polarity and for the already enumerated laws of chemical combination.

In the "nascent state," particles may be regarded either as parabolically perifocal, with the velocity of complete dissociation from a given centre, or as relatively at rest, and ready to obey the slightest impulses of central force. The mean *vis viva* of a system formed by two such particles would be $m \times (\sqrt{2})^2 + m \times 0 = 2\,m \times 1$, representing a change from parabolic to circular orbits and a condensation of two volumes into one.

At the parabolic limit between complete dissociation and incipient aggregation, if the focal abscissa $x_0 = V\,F$, is taken as the unit of wave-length, the value of the successive ordinates, as well as the velocity communicated by uniform wave influence acting through the entire length of the ordinates, will be represented by $\sqrt{4\,x_n}$; the resulting *vis viva*, and the consequent length of path, or major axis, communicable against uniform resistance, by $4\,x_n$; the successive differences of major axis, by 4. Each normal, $v_n\,f_{n+2}$, equals the next ordinate, $v_{n+1}\,f_{n+1}$; there are, therefore, triple tendencies, both in the axis of abscissas, and on each branch of the curve, to successive differences of 4 in the major axes of aggregation, in consequence of the meeting of abscissal, ordinal, and normal waves in the axis, and the meeting of tangential, normal, and abscissal waves upon the curve. At each node of aggregating collision two of the wave systems are due to normally alternating rectangular oscillations,* the third serving as a link between the axial and the peripheral waves. The bisection of the normals, by their equivalent ordinates, adds importance to the normal major axes, and increases the tendency to aggregation at their respective centres of gravity.



*"Fundamental Propositions," 13.

Chemical molecules and atoms are so small that we are unable, at present, to show, so conclusively as in cosmical gravitation, that the "nascent" velocity, or the mean radial velocity at the limit between complete dissociation and incipient aggregation, is equivalent to the velocity of light. But the analogies, which are here presented, are strengthened by the frequent vivid, luminous and thermal accompaniments of chemical change, and by the electric polarity of combining elements. It seems, therefore, reasonably certain that the same limiting unity of velocity and *vis viva*, which can be easily traced in light, heat, electricity and gravitation, is also fundamentally efficient in chemical affinity. M. Aymonnet, in his communication of a "nouvelle méthode pour étudier les spectres calorifiques,"* says: "Je ferai remarquer, avant de terminer, que l'étude des spectres calorifiques d'absorption, faite avec des corps portés à diverses températures, peut et doit conduire à la connaissance de lois physiques reliant les phénomènes d'association et de dissociation des corps aux phénomènes calorifiques et lumineux." In another paper recently presented to the French Academy, "sur le rapport des deux chaleurs spécifiques d'un gaz,"† M. Ch. Simon deduces the theoretical ratio C : c : : 1.4 : 1. The first attempt at a solution of the problem upon *a priori* grounds, appears to have been Professor Newcomb's,‡ who found from the hypothesis of actual collisions, the ratio 5 : 3 if the particles were hard and spherical, or 4 : 3 if they were hard and not spherical; the second, my own,§ based on the general consideration of all internal motions, which led to the ratio 1.4232 : 1; the third, M. Simon's, which took account of rotations and neglected other internal vibrations.

* Comptes Rendus, lxxxiii, 1102—4, Dec. 4, 1876.
† Ib. 727, Oct. 16, 1876. ‡ Proc. A. A. S., v., 112. § *Ante*, xiv, 651.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. VII.

On astrophyllite, arfvedsonite and zircon, from El Paso Co. Colorado, and a colorimetric estimation of titanium before the blow-pipe.

BY GEORGE AUGUSTUS KÖNIG, PH. D.

(*Read before the American Philosophical Society January 19th*, 1877.)

General occurrence. The three minerals are imbedded in quartz. On the specimens which I examined no orthoclase, nor any other species could be found; yet the mother rock may be presumed to be a very coarse grained granite or syenite. Until satisfactory information is received on this point, it must, of course, remain doubtful. In stating that the three minerals occur together, it is but right to say, that I make a hearsay statement.

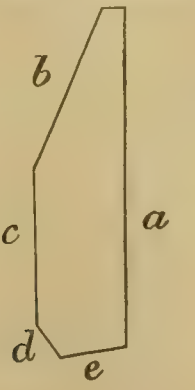
For, the specimens of quartz in which astrophyllite and zircon abound, are destitute of arfvedsonite, and the specimen on which the latter is abundant, does not show either of the two other species. But the character of the quartz, as the common matrix, is strictly identical throughout, of grayish color, locally stained with iron ochre, and massive in structure. The co-occurrence of these three species, at once calls up the close similarity with that of Brevig in Norway, the only locality at which astrophyllite was known to exist. The only difference being that orthoclase forms the matrix at Brevig, and quartz in Colorado.

To Dr. Foote, of this city, I am indebted for the material of this investigation.

I. ASTROPHYLLITE.

Geometrical properties. The crystals exhibit elongated prismatic forms, the cross section being nearly a rectangle on the majority of the individuals. I succeeded in finding some crystals, however, whose section is more complicated and with which I endeavored to establish the angular relations between the several faces. No terminal development of any kind could be observed; the crystals appear all broken across the direction of main extension.

The measured edges are, therefore, all in one zone. The figure represents a cross section of the best developed crystal, and the faces are designated a, b, c, etc., solely in reference to their sequence.



a ∧ c = 180° 15′
a ∧ e = 93°
c ∧ e = 87°
d ∧ e = 119°
b ∧ c = 149° 30′
c ∧ d = 148°

a is a cleavage face and reflects a sharp image, the other faces are true crystal faces, and, with the exception of c, reflect very imperfectly. The largest face (a) is not quite one-eighth of an inch wide. The measurement does not make any pretension of scientific accuracy for the reasons stated, yet the above angles are the means of repeated observations, which only differed by 1°, for the edges a ∧ e, c ∧ e, and by less than 30′ for the other edges. Their approximate accuracy taken for granted, they clearly admit only an interpretation according to the laws of the monosymetric system, when c becomes the basal plane, e an orthopinakoid, b and d hemidomes.

Scheerer, who first described the species (B. H. Ztg. XIII 240, 1854) arrived at a different result. His measurements lead to an orthorhombic interpretation, and the optical investigations of Des Cloizeau (Dana, mineralogy) corroborate his view. But as none of the angles measured by me, find and analogon in those given by Scheerer, no comparison can be made, and future study must decide the truth.

Structural properties. A very marked cleavage exists parallel to the face c, by which the structure becomes eminently micaceous. The cleavage is indicated on the lateral faces by a decided striation (very plainly visible on the quartz, after the removal of crystals), and re-entering angles. Unlike other micaceous minerals, the laminæ are but very slightly elastic and tenacious, being easily reduced to a fine powder. That the crystals break easily across the main extension has already been mentioned. Hardness about 3.

Optical properties. Color from brass yellow to deep bronze brown. Transmitted light deep yellow to reddish brown. Appearance of the powder at a certain degree of fineness like mosaic gold. I could not obtain an image of interference with a lamina, through which types of ordinary print were plainly visible But not possessing much experience in optical investigation, I have referred it to Professor P. Groth, of Strassburg.

Specific gravity = 3.375 at 15 C°.

Pyrognostic properties. The mineral fuses very readily to a black globule in the flame of an oil lamp. With microcosmic salt the reactions for iron, manganese, titanium and silica are easily obtained.

The mineral decomposes completely with sulphuric acid at ordinary pressure, and very readily in a sealed tube at 140 C°.

Composition :

			Oxygen.	
SiO_2	=	34.68	18.485	
TiO_2	=	13.58	5.299	24.363
ZrO_2	=	2.20	0.579	
Fe_2O_3	=	6.56	1.968	2.294
Al_2O_3	=	0.70	0.326	

			Oxygen.		
FeO	=	26 10	5.799	}	
MnO	=	3.48	0.784		
K_2O	=	5.01	0.851		8.256
Na_2O	=	2.54	0.655		
MgO	=	0.30	0.120		
CuO	=	0.42	0.047	}	
TaO_5	=	0.80			
H_2O	=	3.54	3.147	}	3.147
		99.91			

The oxygen ratio becomes :

$$\ddot{R} : \dddot{R} : \dot{R} : \dot{H} .$$
$$32 : 3 : 11 : 4 .$$

$$(H_2O)_4 \quad [(Si\ Ti\ Zr)\ O_2]_{16} \quad [(Fe_2\ Al_2)\ O_3] \quad [(Fe, K, Mn, Na_2)\ O]_{11} .$$

To obtain the atomistic symbol, we have :

					Quotients.	Atoms.
Si	=	16.195	:	28	0.578	13.13
Ti	=	9.281	:	50	0.185	4.25
Fe	=	5.090	:	112	0.044	1.00
Fe	=	20.331	:	56	0.363	8.25
Mn	=	2.696	:	55	0.049	1.11
K	=	4.159	:	39	0.107	2.43
Na	=	1.885	:	23	0.081	1.84
H	=	0.393	:	1	0.393	8.93
O	=	38.060	:	16	2.379	54.07

The most rational approach to these figures will be represented by the symbol

$$\left.\begin{array}{ccc} \overset{IV}{Si_{13}} & & \overset{IV}{Ti_4} \\ \overset{''}{Fe_8} & \overset{VI}{Fe} & \overset{''}{Mn} \\ K_3 & Na_2 & H_{10} \end{array}\right\} \overset{''}{O_{54}}$$

by which all the affinities are satisfied.

Note.—In the above calculation zirconium is converted into its equivalent of titanium, aluminum into ferric iron, magnesium and copper into the bivalent ferrous iron. Tantalic acid was left out, partly because its existence in the mineral is *not* established beyond doubt, and also because the general features of the formula would not be altered by its introduction.

Comparing my analytical results with those of Pisani, Scheerer, et. al. who analysed the Brevig mineral (Dana, mineralogy, ed. 5, 309), whilst a general conformity appears evident, there exists a difference in the percentages of titanium, aluminum and manganese too great to be passed in

silence. To facilitate the comparison, the results of the several analyses are placed side by side :

	Pisani.	Scheerer.	Meinecke.	Sieveking.	König.
$Ti O_2$	7.09	8.24	8.84	8.76	13.58
$Zr O_2$	4.97	——	——	——	2.20
$Al_2 O_3$	4.00	3.02	3.46	3.47	0.70
Mn O	9.90	12.63	12.68	10.59	3.48

Excepting Pisani's analysis, there is such close agreement between the others as could only be accounted for by an identical material and the following of precisely the same methods of analysis under the same circumstances. For, if Pisani's analysis is correct, there must be a variation in the composition of the Brevig mineral. Adding the percentages of $Ti O_2$, $Zr O_2$, $Al_2 O_3$ in Pisani's analysis, we obtain 16.06, against 16.48 in my analysis, whilst those sums in the other analyses are 11.26, 12.30, 12.23 respectively. But in regard to manganese, it seems evident that the mineral from Brevig and that from Colorado differ considerably, being only one third in the latter of that in the former.

It was stated above, that the astrophyllite is closely associated with zircon, which occurs in all sizes from $\frac{1}{4}$ inch to microscopic size. After the astrophyllite has been picked with all possible care, and is reduced to powder in a mortar, an occasional harsh grit is noticed. This suggests the intimate admixture of a hard, granular mineral, probably zircon, and the zirconia found by analysis might only be derived from admixed zircon. To test this question I decomposed the mineral with sulphuric acid of medium concentration, filtered from the insoluble, and digested the residue with sodium hydrate. A white, sandy residue, of great hardness, was obtained, ranging from 3 to 6 per cent. in different samples. I analysed it by itself, and found it to be a mixture of quartz and zircon. Since zircon, even as finest powder, is not acted upon sensibly by sulphuric acid of medium concentration, and as I had avoided the crushing of the hard grains as much as possible, I feel confident to assert that whatever zirconia was found in the sulphuric solution was in molecular combination as astrophyllite, and not derived from admixed zircon. By the same process I made sure that no titanium was present in the form of rutile or titanite, or any other titanium mineral.

I proceed now with the description of a method for the qualitative and quantitative determination of titanium, zirconium and aluminum, which I believe to be new and especially serviceable when the quantity of the mixed metals is very small. The best method for separating titanium from aluminum is stated to be (Rose, quant. analysis) the boiling of the dilute sulphuric solution, when titanium dioxyhydrate will precipitate. This is only relatively true, depending on the relative quantities of metals and of salts in the solution. If the solution be strongly acid, titanium is not completely precipitated, and in certain cases not precipitated at all. (A detailed account of the behaviour of titanium, zirconium and aluminum

will be published hereafter in connection with the reactions of the problematic earth in schorlomite.) If the solution be very neutral, a large percentage of aluminum is precipitated. Owing to this behaviour, titanic dioxyd is often given as alumina, and *vice versa*. When the ferric oxyd, after the supposed precipitation of titanium, is weighed, re-dissolved and estimated by permanganate, the deficit is considered to be alumina, when in reality it is titanium, or zirconium dioxyd. However, my method although applicable to large quantities is more especially designed for small residues, with which precipitations, for physical and chemical reasons, give rise to considerable error.

The mixed oxyds are digested with equal parts of water and concentrated sulphuric hydrate at increasing temperature, until the excess of acid is evaporated. I dissolve now in the smallest possible quantity of water, and bring the liquid upon a watch glass, where a quantity of diammonium sulphate is added, corresponding to the alum equivalent of alumina equal to the weight of the mixed oxyds. A gentle heat is applied until the ammonium salt is dissolved, and the whole is allowed to evaporate spontaneously in a warm place. Under these conditions, titanium, zirconium and aluminum form double salts with ammonium, but those of the two former are very soluble in cold water; while the well-known aluminum double salt, the alum, partly owing to the physical conditions of the crystals, is only slightly soluble in cold water, and still less so in a solution of ammonium or potassium sulphate. Accordingly, the dry mass of salts is moistened with a few drops of cold water, when every salt, but the alum will pass into solution, and the latter salt will be recognized at once, under the lens, by peculiar and constant octahedric forms.

This salt is so granular, that it can readily be freed from accompanying salts by decantation, washing with a solution of ammonium sulphate. Comparative tests showed that this washing process may be continued at length, without effecting a perceptible decrease of the alum. Thus freed from its mother liquor, the crystals may be removed into a small platinum crucible by means of a small piece of filter paper, ignited over the blast lamp, aluminum sesquioxyd obtained in great purity, and its weight ascertained. If the quantity be very small (less than 0.0005 gr.) the filter paper, whose ashes bring in impurity, the crystals may be washed into the crucible with a small amount of boiling water. In this manner I could estimate 0.0001 gr. and obtain a very distinct confirmative test by cobalt nitrate, before the blow-pipe. Experiments demonstrate that the presence of titanium and zirconium sulphates does not interfere with the complete crystallization of aluminum as alum, and as this salt only contains eleven percentum of aluminum sesquioxyd, the sensitiveness of the reaction is readily understood.

Note.—The mixed oxyds must be freed from silica, which is easily accomplished by adding a drop or two of hydrofluoric acid, during their digestion with sulphuric acid.

I am well aware that the determination of aluminum as alum is not new,

but I have nowhere in the literature noticed a recognition of its superiority over other methods, and especially none applying to this separation from titanium and zirconium in a micro-chemical sense.

The mother liquor from the alum, containing the sulphates of titanium and zirconium, besides a considerable amount of ammonium sulphate, is evaporated in a platinum capsule (one with a conical apex preferable, as it facilitates the removal of the oxyds after ignition), evaporated to dryness and ignited with caution over a blast lamp. The oxyds are then left in a scaly condition, very finely divided and well adapted to the subsequent treatment. They might be precipitated by ammonium hydrate and then ignited; but this would cause some inevitable loss, and on the other hand silica would be again introduced by the filter ashes and from the glass vessels, which would interfere with the reactions. The oxyds would be obtained in hard pieces, requiring grinding, and augment the expenditure of work and time generally.

The difficulty, nay, impossibility, of separating titanium from zirconium is well understood by all analysts who have occupied themselves with the subject. I have not overcome these difficulties, but I hope being able to show my co-laborers a way by which a quantitative estimation of the two metals may be arrived at where they occur together. It was proposed already by the great Nepom. Fuchs to reduce titanium dioxyd or chlorid to the sesquichlorid by tin, and estimate its quantity volumetrically. Owing to the unstable nature of the sesquichlorid and other causes not understood, this method fails to give satisfaction. It is also proposed to effect a separation by boiling the acetate solution of the metals. In my experiments I have not been able to obtain anything like constant results, and the difficulty to remove the alkaline salts from the hydratic oxyds, causes errors in small quantities of the oxyds, amounting to twenty-five per cent.

In my prolonged working with titaninum and the earth of schorlomite, I had occasion to produce the blow-pipe reaction many hundred times, and noticing the various shades of color produced with microcosmic salt in the reducing flame, together with their constancy, I conceived the idea to make this reaction the basis of a quantitative colorimetric method. In the first instance it should be useful in determinative mineralogy to distinguish between the several titanium minerals, where a difference of 10 per cent. even would be sufficient to characterize a species. In working up the idea, however, I was astonished to see how rapidly the eye became sensitive to discriminate between the shades and intensities of color on small surfaces. Thus, when analyzing the astrophyllite, more minute and careful experiments proved that a very satisfactory quantitative estimation of titanium dioxyd may be effected when it is mixed with zirconium or other colorless oxyds, which themselves do not produce a coloration with microcosmic salt in the reducing flame. There are but three metals whose presence in even a comparatively small amount will interfere with the accuracy of this method: vanadium, chromium and tungsten. The two former produce a green salt in the reducing flame, the latter a deep sky blue.

I called attention to the effect of vanadium on the titanium reaction some time ago (Proceedings Acad. Nat. Sciences, March, 1876), when it was stated that the two metals, producing complimentary colors –red and green—will extinguish each other ; vanadium, however, may be recognized by its deep yellow color in the oxydizing flame, which is most intense at low temperature, while the yellow of titanium only shows at high temperature, just below red heat. This point is not only of general interest, as a case which might possibly present itself to the analyst, but is of direct practical importance, since I have found vanadium in all the titanium minerals of Magnet Cove (Proceedings Acad. Nat. Sciences, March, 1876), and became aware of its existence just by applying this colorimetric method, to the small residues obtained from the iron sesquioxyd, by means of citric acid and ammonium sulphide. Here the titanium had escaped precipitation by boiling, and would have been called alumina, since it formed a nearly white powder and did not give the amethyst red color in the reducing flame. However, vanadium and chromium may be removed from the oxyds by fusion with potassium or sodium nitrate, a treatment which should never be omitted, if the highest degree of accuracy is desired in analysis.

Practical execution of the method. I prepare titanium dioxyd and aluminum sesquioxyd, the former from rutile, the latter from alum, in the finest possible division, by igniting their respective ammonium citrates or tartrates, removing at the same time the last trace of iron by ammonium sulphide. In this fine condition the oxyds are very readily dissolved by the acid sodium phosphate before the blow-pipe. I then weigh out 0.1 gr.; 0.095 gr.; 0.090 gr.; 0.085 gr.....0.005 gr. of each of the oxyds, and mix them together inversely by very careful trituration in the mortar. I produce thus one series containing in

TiO_2	Al_2O_3
100	0
95	5
90	10
85	15
⋮	⋮
0	100

These twenty samples, of one decigramme each, I put in well corked glass tubes with their respective number ; they form the standard. 0.002 gr. of the standard mixture, and an equal weight of the unknown mixture are dissolved in equal quantities of microcosmic salt. For very accurate determination it is necessary to weigh the salt (0.12 gr.), but with some experience it is sufficient to form a circular loop on the platinum wire one-eighth of an inch in diameter, then to add gradually of the salt until the bead is nearly spherical, possessing one-eighth inch thickness. I use a guage for this purpose formed of two pins, whose points are one-eighth

inch apart, and between which the bead is made to pass with slight friction. In order to dissolve the entire 2 milligrs., I bring the powder from the scale pan on a square piece of Swedish filter-paper quarter inch square, and place this upon a dark polished surface (bottom of an agate mortar). With the last particles of the oxydes the paper is made to adhere to the bead, burnt and thus no loss is possible. I keep a series of ten beads (from 10–10 per cent.) hermetically sealed in a glass tube for a primary comparison, and having thus established approximately the position in the scale, it is easy to select one directly above and another below, with which to compare. Any person accustomed to make colorimetric observations with liquids will be able to use this method at once, without any special practice. As the reflection from the spherical surface interferes to a certain extent with the adjustment of the color in the scale, I prefer flattening the beads upon a heated steel anvil with a polished hammer, also heated, to prevent a too rapid chilling of the glass.

The thickness of the wire determines the thickness of the glass. I place the several glass plates alongside each other upon a flat porcelain slab, by which means the slightest difference in shade and depth may be recognized. The intensity of color is much greater towards the pure titanium than towards the zero; the blue rays being entirely absorbed by the glass at 25 p. TiO_2, the glass being then purely pink. I am now experimenting upon the feasibility of extinguishing the color of the titanium by a graduated scale of green, representing per cent of titanium, by which means I am led to believe this colorimetric method, before the blow-pipe, will be made easier and more perfect.

2. Arfvedsonite.

Crystallographical properties. The crystals are elongated prisms with the clinopinakoid. As the faces are of equal width the cross section forms an equilateral hexagon. No terminal faces could be observed. The obtuse prismatic angle was found 124° 30′ with the hand goniometer. The habitus is altogether like that of common hornblende. In one large crystal, which I obtained loose, measuring nearly 4 inches in length by one inch in width, I noticed a disaggregation similar to that observed in uralite, that is to say, the crystal breaks up, or crumbles into an infinite number of small individuals. The principal direction of this parting appears to be a plane parallel to the orthopinakoid, a face not developed in the crystal. These small individuals exhibit brilliant faces and give a prismatic angle of 124° 5′ on the reflexion goniometer. On the smaller and more compact crystals, which are imbedded in quartz, I observed a cleavage parallel to the orthopinakoid quite as marked as that parallel to the prism. I could not measure the angle accurately, but it appeared larger than the angle of the prism. The *color* is raven black (after removing superficial impurities by hydrochloric acid), the *lustre* submetallic, and the color of fine powder is lavender blue.

Hardness = 6.

Specific gravity = 3.433 at 12 C° (with coarse powder). *Before the blowpipe* melts easily to a black glass in the flame of oil lamp. With microcosmic salt gives the reaction of silica, iron, manganese, and with difficulty that of titanium. Colors the flame yellow. Imperfectly decomposed by fusion with K H S O_4, not acted upon by hydrochloric and sulphuric acid at atmospheric pressure, and very slowly decomposed with sulphuric acid in a sealed tube at 160 C°.

Composition :			Oxygen.		
SiO_2	=	49.83	26.409		
TiO_2	=	1.43	0.558	27.164	5.702
ZrO_2	=	0.75	0.197		
Al_2O_3	=	trace			
Fe_2O_3	=	15.88	4.764	4.764	1.000
FeO	=	17.95	3.985		
MnO	=	1.75	0.385		
Na_2O	=	8.33	2.149	6.928	1.454
LiO					
K_2O	=	1.44	0.245		
MgO	=	0.41	0.164		
Ignition	=	0.20			
		97.97			

$\ddot{R} : \dddot{R} : \dot{R} = 17 : 3 : 4.3$

To obtain the atomic ratio, we have :

					Quotient.	Atoms.
Si = 0.836				Si =	0.8475	8.56
Ti = 0.017	Si =	0.0095		Fe =	0.099	1.00
Zr = 0.006	Si =	0.0020		Fe =	0.278	2.809
Fe = 0.099				Na =	0.286	2.88
Fe = 0.249				O =	2.428	24.52
Mn = 0.025						
Na = 0.268						
K = 0.031	Na =	0.018				
Mg = 0.010	Fe =	0.004				
O = 2.428						

and the nearest symbol will be

$$\left.\begin{matrix} & & \overset{IV}{Si_3} \\ \ddot{Fe}_3 & \overset{VI}{Fe} & Na_3 \end{matrix}\right\} \ddot{O}_{24}$$

It is apparent that neither the oxygen ratio, nor the atomic ratio lead to a very satisfactory formula, in as much as the formula given contains one-half atom of oxygen more than required to satisfy the affinities of the metals.

Owing to the extreme cleavage of the mineral, a sufficiently thin section could not be prepared to allow a microscopical and optical examination; and the presence or absence of minute particles of other species could therefore not be ascertained. The analysis was conducted with great care, of every constituent a check determination was obtained. Three alkali determinations gave identical results. Only the ferrous iron was but once determined. After being in sealed tube for nearly a week, the mineral was not completely decomposed. After titration I filtered from silica and undecomposed part, removed silica by sodium hydrate, and from the weight of residue I calculated the ferrous iron pro toto. In the face of the duplicate and closely agreeing determinations I cannot explain the deficiency of two per centum in the analysis.

3. Zircon.

Occurs in brilliant, mostly iron black crystals, imbedded in quartz or in astrophyllite. The size varies from microscopic dimensions to $\frac{1}{4}$ inch pyramidal edge.

Crystallographical properties. The form is a combination P. ∞P. 0P. I observed the basal plane on every crystal which I examined. It is sometimes very small, but mostly very plainly developed and splendent. On one crystal it appeared distinctly rhomboid, and this induced me to measure the angles of the pyramidal edge, which I found 120° 56′; 123° 15′. But all other crystals gave as nearly 123° as the uneven faces could be expected to average. The rhomboidal crystal stands, therefore, alone as a distorted individual. The prism is generally very small, often only a splendent edge.

When boiled with strong hydrochloric acid the black color disappears, and the substance exhibits a yellowish flesh color. The individuals appear corroded. Otherwise, physical characters identical with those of other localities.

Specific gravity at 12 C° = 4.538.

Composition:

SiO_2	=	29.70
ZrO_2	=	60.98
Fe_2O_3	=	9.20
MgO	=	0.30
		100.18

The coarse powder of the mineral had been boiled for some time with strong hydrochloric acid, until no more iron was dissolved. The unusually large percentage of iron still shown by the analysis must reasonably be considered as belonging to the mineral.

Note.—While this paper is in press, I obtained other specimens from El Paso County, in which a black mica occurs in large foliated masses, traversed by astrophyllite. This and another mineral, apparently arfvedsonite changed into a micaceous mineral, I am investigating at present.

A measured section of the Palæozoic Rocks of Central Pennsylvania, from the top of the Allegheny River Coal Series, down to the Trenton Limestone in the Lower, or Cambro-Silurian System.

By Charles A. Ashburner,

Asst. 2d Geol. Surv. Pa.

(*Read before the American Philosophical Society, February* 16, 1877.)

The following long section of the Palæozoic strata of Huntingdon County, Pennsylvania, is the result of an instrumental study of a district bounded on the west by Broad Top Mountain ; on the north by the East Broad Top Railroad ; on the east by Blacklog Valley ; on the south by Sideling Hill Creek.

Two vertical sections were constructed along cross section lines, in a north-west direction, from the Trenton limestone of Blacklog Valley to the Broad Top coal basin, a number of other shorter sections were made along selected portions of the district between the two longer lines.

The results of the measurements made on these several lines of survey, sufficiently near together to check one another, are given in the following pages.

The whole height of the vertical section, from the top of the Mahoning sandstone in the Coal Measures down to the bottom of the Trenton limestone, is eighteen thousand three hundred and ninety-four feet (18,394′), distributed as follows :

Carboniferous Strata*.....at least.	3,777′	
Devonian Strata.....	7,975′	
Oriskany Sandstone†.....	58′	=18,394′‡
Upper and Middle Silurian.....	4,214′	
Lower or Cambro-Silurian.....at least.	2,370′	

This section would therefore represent the record of a shaft or bore hole 3½ miles deep, sunk from the surface of the land of the Broad Top Coal Basin at Broad Top City.

Carboniferous.

No. XIII.

Alleghany River (*Lower Productive*) *Coal Measures*. ..... 264′

267. Mahoning Sandstone. A white conglomerate sandstone, containing a softer shaly mass and a coal bed..... 90′

* The base of the carboniferous being in dispute, the term is here made to include the Pocono, Vespertine, or Upper Catskill, X, for reasons evident in the section.

† Geologists may include the Oriskany in the Devonian or in the Silurian as they see proper.

‡ To get this total the measurements of the rocks *above* the Clinton lower olive shale at Saltillo are added to those of the rocks *below* that horizon at Orbisonia.

266. Sandstone and shale, *containing a small bed of coal*, in black slate and shale, a short distance below the bottom of the Mahoning Sandstone, probably representing Coal E, Upper Freeport. Lower part, directly above Coal D, hard, rather massive black slate. ..... 45′

265. Coal bed D, (top bench mine C).....2′1″
264. Black fissile slate containing seams of coal varying in thickness from ¼ to ⅛ inch.....0′4″
263. Coal bed D, (middle bench).....0′2″
262. Slate containing a stratum of sandstone about the centre .....2′1″
261. Coal bed D, (bottom bench). Fireclay floor of the mines unmeasured.....3′1″ } 7′9″

260. Sandstone and shale; black slate lower part..... 45∓′

259. Coal bed C, (top bench mine B).....1′6″
258. Hard grayish-black slate, (varying thickness)...0′4″
257. Coal bed C, (bottom bench). Fireclay floor of the mines unmeasured.....2′0″ } 3′10″

256. Sandstone, shale and slate..... 30′

255. Coal bed B, (top bench mine A). .....1′ 6″
254. Rock and fireclay.....1′ 4″ } 4′8″
253. Coal bed B, (bottom bench).....1′10″

252. Sandstone and shale..... 35′

251. Coal bed *A*, underlaid by a carbonaceous black fireclay, commonly called black gravel..... 2′ .

No. XII

Pottsville (Seral) Conglomerate (Millstone Grit.)..... 280′

Upper Member. *Piedmont Sandstone.*

250. Upper member consisting of three parts, upper white and reddish white and gray flaggy sandstone and conglomerate; in the middle part the conglomerate predominates, the pebbles are larger but irregularly distributed, the strata exhibiting false bedding to a marked degree; while the lower part is composed principally of thinly bedded and conglomeratic sandstone..... 160′

Middle member (*Kanawha River Coal Series*).

249. Sandstone and shale, " " ..... 14′
248. Coal (Fireclay floor unmeasured)..... 2′
247. Less massive gray sandstone exhibiting false bedding.. 17′
246. Dark gray and black slate and slaty sandstone..... 7′

Lower member (*Conglomerate proper.*)

245. Hard massive gray sandstone, strata fractured in a perpendicular and also oblique direction to the bedding, surfaces

stained and coated with ferric oxide, containing impressions of calamites, lepidodendra leaves and sigillaria..... 10′

244. Upper part consists of a hard massive gray and white sandstone and conglomerate, the latter predominating toward the central part where the pebbles are large; while in the lower part there is less conglomerate, the sandstone becoming dark gray and flaggy, containing micaceous specks..... 70′

No. XI.

Mauch Chunk (Umbral) Red Shale..... 1100′

Upper Member.

243. Brown silicious and shaly hematite, varying thickness.
242. Yellow argillaceous sand shale 5 ± feet.....
241. Yellow and greenish-yellow flaggy sandstone with slight alternations of green argillaceous shale 20 ± feet.... } 150′
240. Red and gray sandstones, and shales, rather flaggy and argillaceous .....

[At the west end of Wray's Hill Tunnel.]

239. Very soft bright red shale..... 59′
238. Hard grayish-red sandstone showing false bedding... 41′
237. Red sandstone containing white calcareous seams along planes of false bedding..... 48′
236. Softer red sandstone..... 28′
235. Dark grayish-red sandstone, much harder and exhibiting false bedding and perpendicular fracture..... ..... 14′
234. Friable soft bright red sandstone and shale..... 93′

[At the east end of Wray's Hill Tunnel.]

233. Partly concealed. Probably composed of red and gray sandstone with alternations of red and gray shales and flags.. 300′
232. Probably red shales and sandstone..... 177′

Middle member (*Mountain Limestone.*)

231. Red shaly limestone ..... 3 ±′
230. Red shale very argillaceous..... 10 ∓′
229. Soft argillaceous red shale..... 5′
228. Massive silicious red limestone (easily weathered) containing *Terabratula Rœmingeri, Grammysia, Strophodonta, Rhynchonella*..... 2′6″
227. Very soft red shale..... 2′
226. Red and gray mottled, calcareous shale (concretionary) contains *Centronella* ..... 3′
225. Red calcareous shale and limestone..... 9′
224. Variegated red and gray massive limestone..... 1′
223. Gray massive limestone..... 3′
222. Red shale..... 6′
221. Greenish-gray argillaceous limestone..... 4′

Lower member.

220. Concealed	3′
219. Partly concealed. Probably composed of massive red silicious sandstone and shale with alternations of gray sandstone and flags	114′
218. Coarse grained greenish-gray sandstone overlaid by red shale	3′
217. Heavy argillaceous gray sand shale, conchoidal fracture containing streaks of hematite and manganese	7′
216. Reddish-gray, sandy slate colored with ferric oxide	3′
215. Very hard, flinty greenish-gray, massive sandstone	7′
214. Alternating brittle green and red shale	2′
213. Hard, dark-gray sandy slate	2′

No. X.

Pocono (Vespertine) Gray Sandstone	213′

Upper member.

212. Partly concealed. Composed for the most part of hard, coarse grained, massive, brownish-gray and gray sandstone, alternating with thinly bedded and flaggy sandstone, and shale of the same color. Near the top a few beds of red shale and sandstone	580′

[At the west end of Sideling Hill tunnel.]

211. Massive gray sandstone surfaces coated with ferric oxide	8′
210. Alternating massive gray and greenish-gray sandstone containing a twelve inch seam of black slate showing impressions of minute plants	22′

Middle member, upper part.
(*New River Coal Series*).

209. Massive gray sandstone containing thin partings of coal.	29′
208. Gray argillaceous sand	5″
207. Coal (seam No. 19)	2½″
206. Soft greenish-gray micaceous shale	1′3″
205. Light gray, massive sandstone containing thin plates of coal and micaceous specks	56′
204. Sandstone containing thin partings of coal	1′
203. Soft, loose sandstone containing seams of coal, running irregularly through the mass, amounting in all to about 5 inches	6′
202. Massive sandstone containing in its lower part plates of coal	12′
201. Poor, bony coal (Seam No. 18)	2″
200. Sandstone	1′6″
199. Argillaceous sand	¼″
198. Coal (Seam No. 17), maximum thickness 9 inches	3″

197. Argillaceous sand containing plates of coal..... 4″
196. Gray sandstone containing between the strata a great deal of loose sand..... 15′
195. Gray sandstone containing nodules of pyrites and plates of coal in the upper portion of the mass..... 26′
194. Coal very much broken up. (Seam No. 16)..... 1″
193. Sandstone containing nodules of iron pyrites..... 2′6″
192. Coal (Seam No. 15); brilliant lustre, rhombohedral fracture, resembling bituminous coal ..... 1″
191. Sandy fireclay..... 6″
190. Coal (Seam No. 14)..... 1″
189. Sandstone with thin partings of coal in the lower portion..... 4′
188. Sandstone..... 9′
187. Fireclay..... 1″
186. Shaly sandstone..... 34′
185. Coal (Seam No. 13)..... 1″
184. Alternating shaly and massive, gray sandstone..... 6′
183. Poor bony coal (Seam No. 12)..... 3″
182. Shaly sandstone..... 6′
181. Coal (Seam No. 11); very much broken up and associated with red sand..... 1″
180. Shaly sandstone..... 4′
179. Coal (Seam No. 10) maximum thickness 6 inches..... 3″
178. Shaly sandstone..... 2′
177. Coal (Seam No. 9) ..... 1″
176. Shaly sandstone..... 1′
175. Coal with sandstone above and below (Seam No. 8) 1″
174. Gray sandstone..... 36′
173. Steel gray shale of a greasy lustre..... 8″
172. Coal (Seam No. 7)..... 1″
171. Fire clay..... 1″
170. Sandstone..... 5′
169. Coal (Seam No. 6)..... 1″
168. Sandstone ..... 10″
167. Coal (Seam No. 5) resembling very much specimens from Montgomery County, Virginia..... 2″
166. Soft sandstone..... 5″
165. Coal (Seam No. 4)..... 2″
164. Sandstone containing loose brown, argillaceous sand.. 14′
163. Loose sand shale, surfaces coated with acicular crystals of sulphate of alumina formed by the decomposition of pyrites..... 3′
162. Coal; very much broken up by false bedding and containing a great deal of iron pyrites (Seam No. 3)..... 2″
161. Massive, gray sandstone having a rhombohedral fracture and containing specks of slate and ferruginous matter.... 28′

160. Coal (Seam No. 2); very much broken up by false bedding..... 1″
159. Soft, gray, shaly sandstone exhibiting false bedding.. 5′
158. Poor bony coal (Seam No. 1)..... 1″

Middle member. Lower part.

157. Soft, black shale containing plates of coal and impressions of minute plants, surfaces stained with ferric oxide; alternating with a fine grained conglomerate containing micaceous specks..... 25′
156. Yellowish-gray, argillaceous shale containing thin plates of coal. Surfaces showing "slicken sides."..... 26′
155. Sandstone..... 9′
154. Black, carbonaceous slate enclosed in hard massive sandstone..... 2″
153. Hard, massive, gray sandstone..... 17′
152. Hard, conglomeritic, light gray sandstone containing a few alternations of black slate..... 51′
151. Hard, massive sandstone alternating with gray slaty micaceous sandstone..... 45′
150. Soft, gray shale..... 1′
149. Alternating dark gray, flaggy and slaty sandstone containing micaceous scales..... 33′
148. Dark gray, argillaceous shale with talcy lustre..... 39′
147. Dark greenish-gray shale, with talcy lustre, containing acicular crystals of sulphate of alumina formed by the decomposition of pyrites..... 10″
146. Soft, black slate..... 3″
145. Massive, gray sandstone..... 3′
144. Soft, gray, argillaceous shale..... 5′6″
143. Massive, hard gray sandstone..... 25′
142. Fine grained, light gray conglomerate alternating with thin strata of black micaceous sandstone..... 13′
141. Fine grained, dark gray, argillaceous shale alternating with a hard, gray sandstone interstratified with a black micaceous sandstone..... 26′
140. Massive, flinty gray sandstone alternating with yellowish-gray sandstone showing false bedding..... 17′
139. Soft, gray shale..... 1′3″
138. Hard, gray sandstone..... 1′6″
137. Soft, gray shale..... 1′6″
136. Soft, yellowish gray shale of a talcy lustre..... 1′6″
135. Very hard, massive bluish-gray sandstone, with occasional seams of a lead-colored clay..... 4′
134. Hard, massive gray sandstone..... 13′
133. Gray slaty sandstone..... 10″
132. Carbonaceous shale..... 5″

131. Gray shale..... 3″
130. Black coal slate..... 2″
129. Gray sand shale..... 3′4″
128. Black slate..... 4″
127. Hard, massive gray sandstone alternating with yellowish gray, argillaceous sand shales..... 15′

Lower Member.

126. Dark bluish-gray slaty sandstone alternating with a shale of close texture..... 22′
125. Alternating gray, green and yellow shale..... 25′
124. Green shale containing *Cypricardina* and *Orthis*. ... 5′

[At the East end of Sideling Hill Tunnel.]

123. Partly concealed. Alternating as above but softer.... 25′
122. Hard, coarse-grained reddish-gray sandstone alternating with soft, yellow sandy shale..... 165′
121. Coarse-grained yellow sandstone. Surfaces stained with iron, alternating with grayish-brown sandstone..... 12′
120. Alternating yellow, gray and green shaly sandstone.. 44′
119. Soft yellow, sandy shale interstratified with a gray flaggy sandstone, alternating with a brown sandstone containing micaceous specks..... 50′
118. Flaggy olive sandstone alternating with a greenish-gray sandstone containing iron concretions. Partly concealed..... 42′
117. Partly concealed. Soft green and olive sandstone alternating with soft, yellow, flaggy and hard, massive gray sandstone containing ferruginous specks and having a distinct rhombohedral fracture..... 440′

Devonian.

No IX.

Catskill (*Ponent*) *Red Sandstone*..... 2680′

116. Concealed. Probably composed of red shales and sandstone alternating with white and gray sandstones.....175′
115. Greenish-gray, slaty sandstone containing micaceous specks alternating with soft, bright red shale..... 100′
114. Massive, coarse-grained, reddish-gray sandstone alternating with red shale and sandstone..... 125′
113. Very silicious brown hematite, thickness undetermined, but variable..... ——
112. Partly concealed. Consisting for the most part of red flaggy sandstone and shale alternating with massive yellow, gray and white shaly sandstone.....1520′
111. Red, sandy and argillaceous shale; lower part contain-

ing fucoid stems and showing a fine exhibition of ripple marks..... 270′

110. Red, massive sandstone and shale with slight alternations of green sandy shale and massive brown sandstone, particularly toward the lower part..... 140′

109. Red shale and sandstone alternating with gray shale and massive gray sandstone; containing small deposits of coal. 290′

108. Light yellow, sandy shale alternating with friable red shale; surfaces stained with bituminous matter. Lower part brownish-gray sandstone containing micaceous specks..... 60′

Transition Strata between IX and VIII..... 90′

107. Yellowish-white, argillaceous sand shale lower part containing lepidodendra and calamites..... 8′

106. Red sandstone and shale, containing ripple marks, with slight alternations of green shale..... 18′

105. Alternating olive-green sandstone and shale, lower part of a darker green color..... 10′

104. Greenish-gray sandstone and shale; upper 10 feet containing quartz crystals; lower part fossiliferous..... 15′

103. Alternating red sandstone and shale..... 25′

102. Green fissile shale..... 1′

101. "Larry's Cr. ore bed," ranging from 4 inches to 1 foot thick, containing *Spirifer disjuncta* and *Rhynchonella*..... 8″

100. Green fissile shale containing two sandstone strata, 2 inches thick, upper surfaces showing ripple marks and under surfaces containing impressions of fucoid stems..... 3′

99. Fossiliferous, brownish gray sandstone containing *Spirifer disjuncta*, &c..... 1′

98. Dirty white sand shale containing plant impressions.... 3″

97. Yellowish-red sandstone..... 5′

96. Red shale, easily weathered, containing occasional seams of sandstone and green shale a few inches thick..... 3′ +

No. VIII.

Chemung (Vergent) Shales..... 1860′

95. Partly concealed. Consisting, for the most part, of olive and brown argillaceous sandstone and shale, containing alternations of red fissile shale. Readily weathered into clay.... 245′

94. Massive dark-gray sandstone containing ferruginous specks alternating with reddish-gray, flaggy sandstone..... 15′

93. Upper part fossiliferous greenish gray sandstone; lower part alternating soft red and light green sandy shale..... 100′

92. Massive brown sandstone. Surfaces stained with iron and coated with minute quartz crystals, alternating with light red shale, showing impressions of fucoids..... 70′

91. Red, brown and gray sandstone. The lower part is composed principally of red and olive sand shale containing micaceous specks; surfaces of the olive shale very much stained with iron..... 140′

90. Partly concealed. Consisting for the most part of hard, massive, gray and brown sandstone, containing micaceous specks, alternating with softer shaly strata..... 500′

89. Partly concealed. Composed principally of massive, gray and brown sandstone, containing yellow and red specks, alternating with softer sandstone and shale; the softer strata predominating more than in No. 90, being marked by sharp narrow ravines running parallel with the strike..... 490′

88. Brown, green and gray massive and flaggy sandstone; surfaces very much stained with iron..... 80′

87. Partly concealed. Consisting for the most part of red and olive shale and sandstone; former predominating..... 100′

86. Massive reddish-brown sandstone containing micaceous specks..... 10′

85. Massive reddish-brown sandstone, containing micaceous specks, and shale alternating with brown argillaceous sandstone containing crinoid stems..... 110′

Portage (Verjent) Flags..... 1450′

84. Partly concealed. Consisting for the most part of hard, massive brown and gray sandstone with alternating strata, from 10′ to 30′ thick, of soft olive and gray shale, marked in some cases by sharp narrow ravines running parallel to the strike..... 500′

83. Massive brown sandstone, containing iron specks, alternating with shale..... 40′±

82. Light fawn colored, argillaceous shale alternating with greenish yellow, flaggy sandstone; surfaces coated with minute quartz crystals..... 70′

81. Partly concealed. Composed principally of yellow, green and light olive shale alternating with occasional seams of brown and gray sandstone..... 140′

80. Light fawn colored, yellow and green argillaceous shale alternating with soft olive brown and green flaggy sandstone; latter containing yellow and red specks and surfaces stained with iron..... 100′

79. Light olive shale with yellow and red stains, lower part very fissile..... 80′

78. Yellow shale containing a few alternating seams of sandstone..... 80′

77. Dark olive and yellow argillaceous shale..... 120′

76. Light olive shale containing alternations of thinly laminated sandstone strata, from 1 to 2 inches thick..... 100′

75. Same in character as No. 73, but with the sandstone predominating..... 60′

74. Dark olive shale containing seams of shaly sandstone, stained bright red with ferruginous matter. ..... 50′

73. Olive, red and yellow shale..... 10′

72. Gray sandstone with a few alternating beds of olive shale. 35′

71. Fine grained, greenish-gray sandstone, in seams from 4 to 6 inches thick, alternating with fine-grained, olive fissile slate..... 65′

Genesee (Cadent Upper) Slate..... 325′

70. Partly concealed. Olive slaty and shaly sandstone alternating with brownish gray, flaggy sandstone and a few beds of olive shale..... 100′

69. Light olive and greenish-gray argillaceous shale and slate..... 75′

68. Partly concealed. Probably same in character as No. 69..... 100′

67. Dark olive, fissile slate with occasional seams of a bright brown-colored sandstone, 2 to 4 inches thick..... 50′

Hamilton (Cadent) Shales..... 635′

66. Partly concealed. Consisting for the most part of gray sandstone flags and shales containing fossils as in No. 65, but not as abundant..... 250′

65. Upper part, hard, massive greenish-gray and flaggy olive sandstone, lower part light, olive, slaty sandstone. Surfaces very much stained with iron. Contains: *Aviculopecten princeps, Chonetes mucronatus* and *coronata, Grammysia, Spirifer granulifera* and *mucronatus*, and *Tentaculites. Algæ* more particularly Spirophyton *caudagalli*..... 85′

64. Partly concealed. Consisting for the most part of massive, gray and flaggy sandstone alternating with beds of thinly laminated, fissile shale (fossiliferous)..... 200′

63. Thin, gray, calcareous, flaggy sandstone, and seams of greenish-gray, fragile sandstone alternating with gray and dark olive shale..... 100′

Marcellus (Cadent Lower) Black Slate..... 875′

62. Partly concealed. Composed principally of gray and brown shale alternating with flaggy and slightly calcareous sandstone..... 200′

61. Argillaceous gray, olive and brown shale very much stained with iron and bituminous matter..... 200′

60. Partly concealed. Consisting for the most part of brown, gray and black argillaceous shale with occasional seams of sandstone..... 171′

59. Gray, shaly, argillaceous limestone alternating with greenish-gray lime-shale (local deposit?)..... 20′
58. Black fissile slate and shale, surfaces very much stained with iron and coated with bituminous matter..... 100′
57. Black slate and brown shale, surfaces stained with iron and coated with bituminous matter; the shale in the lower part directly above the iron ore bed is very argillaceous..... 180′
56. Marcellus iron ore bed, varying thickness..... 4′

Upper Helderberg (Post Meridian) Limestone ..... 60′

55. Dark blue limestone containing seams of calcite..... 4′
54. Dark brownish-gray argillaceous lime shale..... 2′
53. Dark blue argillaceous limestone..... 2′
52. Dark bluish-gray lime shale and light olive calcareous shale..... 7′
51. Dark greenish-gray lime shale..... 1′
50. Concealed. Shaly limestone (?) ..... 7′
49. Dark olive calcareous shale easily weathered..... 22′
48. Massive gray argillaceous limestone..... 5′
47. Fragile dark olive and yellow argillaceous limestone... 10′

46. *Scholarie* and *Caudagalli*, both wanting, but perhaps represented by clay and shale on top of the Oriskany.

No. VII.

Oriskany (Meridian) Sandstone..... 58′

45. Upper part ocherous clay, lower part coarse-grained ferruginous and calcareous sandstone..... 12′
44. Friable sand containing pebbles size of a pea..... 15′
43. Coarse-grained arenaceous sandstone more fragile than above and breaks into more irregular shapes. Mass stained with ferruginous matter and surfaces coated with red hematite. Contains: *Cyrtoceras expansus, Dalmania micrurus, Eatonia peculiaris, Megambonia lamellosa, Orthis hipparionyx, Platyceras ventricosa, Pterinea texilis, Rensselæria marylandica, Rensselæria ovalis, Rensselæria ovoides, Spirifer arenosus, Spirifer arrectus.* Oriskany hermatite ore bed, locally deposited at the lower horizon..... 31′

SILURIAN.

No. VI.

Lower Helderberg.

Lewistown (Pre-meridian) Limestone..... 162′

42. Partly concealed. Upper part composed principally of shaly, argillaceous limestone with probably a few beds of crys-

talline limestone, while the lower part is made up principally of the latter. ..... 30′

41. Massive, dark blue, crystalline limestone..... 42′

40. Massive, bluish-gray limestone, parts of which are characterized by a conchoidal fracture..... 20′

39. Massive, brownish-gray, and blue, crystalline limestone containing alternating beds of gray shale limestone..... 20′

38. Massive, gray, crystalline and dark blue, argillaceous limestone with occasional beds of light gray, shaly limestone and lime shale. Contains: *Acervularia, Alveolites minima, Alveolites, Astylospongia inornata, Merista lævis, Orthis oblata, Pentamerus galeatus, Rhynchonella formosa, Astylospongia, Atrypa reticularis, Aulopora, Conophyllum, Merista arcuata, Stromatopora, Trematospira formosa, Zaphrentis*..... 50′

Water-lime (Scalent) Cement Beds..... 580′

37. Partly concealed. Consisting for the most part of blue and gray, thinly laminated, argillaceous limestone..... 150′

36. More massive, bluish-gray, argillaceous limestone thinly laminated. The massive strata have a conchoidal fracture... 110′

35. Massive, dark gray and bluish-gray limestone, surfaces coated with carbonaceous matter and showing "slicken sides." Also contains calcite with a marked cleavage. Lower part contains impressions of fucoids and bivalve shells..... 30′

34. Partly concealed. Similar to No. 35 but containing lime shale..... 90′

33. Massive bluish-gray limestone alternating with slaty argillaceous limestone and green and yellow calcareous shale. 50′

32. Partly concealed. Principally yellow and gray, argillaceous lime shale..... 60′

31. Gray and bluish-gray, slaty, argillaceous limestone and shale..... 20′

30. Thinly laminated, blue and yellow argillaceous limestone alternating with gray lime shale..... 20′

29. Brownish-gray and gray, slaty limestone containing seams of calcite..... 30′

28. Bluish-gray slaty limestone and lime shale..... 20′

Onondaga (Salina) (Scalent) Marls..... 440′

27. Yellow, brown, gray and green, argillaceous and calcareous shale..... 20′

26. Partly concealed. Composed principally of olive and gray calcareous shale..... 50′

25. Gray, shaly limestone alternating with olive, calcareous shale..... 100′

24. Partly concealed. Composed for the most part of yellow

and green, calcareous shale alternating with red, argillaceous shale... ..... 70′

23. Partly concealed. Composed for the most part of green, yellow and gray, calcareous shale alternating with red shale.. 150′

22. Olive and gray, calcareous shales with a few alternating beds of red shale..... 50′

No. V.

Clinton (Surgent) Red Shale..... ..1145′

21. Red, sandy shale containing irregular deposits of green shale. The red shale is more silicious and massive toward the upper part, where it exhibits a rhombohedral fracture..... 120

20. Partly concealed. Probably composed of red, argillaceous shale containing alternations of green and gray, calcareous shale..... 100′

19. Red, shaly sandstone containing irregular seams of calcite, becoming argillaceous toward the bottom..... 50′

Clinton upper Olive Shale..... 162′

18. Gray, olive and yellow, calcareous shale containing seams of blue, fossiliferous limestone..... 30′

17. Olive and olive-brown, argillaceous and calcareous shale containing seams of blue, fossiliferous limestone..... 80′

16. Similar to No. 17, but containing more seams of limestone toward the bottom..... 40′

15. Blue and gray, argillaceous limestone alternating with dark olive shale; lower part composed of light yellow, argillaceous lime shale, forming the hanging wall of the fossil ore bed. The Clinton upper olive shale contains the following fossils, more particularly in the lower part: *Atrypa reticularis, Beyrichia lata, Buthotrephis gracilis, Dalmania limulurus, Homalonotus delphinocephalus, Orthis elegantula, Platyostoma niagarensis, Pterinia emacerata, Rhynchonella neglecta, Strophomena rhomboidalis*..... 12′

Clinton Ore Rocks..... 53′

14. Upper fossil ore bed..... 10″
13. Red sandstone and white shale..... 12″ } 3′
12. Lower ore bed..... 14″

These are asserted to be safe average thicknesses of these three beds, by H. G. H. Tarr, Superintendent of Rock Hill Iron and Coal Co. at Orbisonia.

11. *Ore Sandstone.* Its upper part is composed of massive, yellow sandstone under ore bed at Rockhill, while at Saltillo the upper part is very calcareous. The central part is composed of yellow and green, fossiliferous sandstone (crinoid stems) alternating with shale, while the lower part becomes much more massive ..... 50′

Clinton lower olive shale..... 660′

10. Yellow, gray and green, argillaceous shale weathering olive and claret color, near the lower part the surfaces of the shale are stained with iron and bituminous matter..... 600′

9. Same as No. 10. Lower part containing soft olive shale, showing impressions of crinoid stems (Three Springs), and red shale (Rockhill), containing by analysis 4.29 per cent. of metallic iron..... 60′

No. IV.

Medina (Levant) Sandstone..... 1330′

8. Massive, white and light gray, fine-grained, hard sandstone alternating near its upper limit with beds of red and greenish shale. Contains *Arthrophycus harlani*..... 400′

7. Soft, argillaceous brown and red sandstone and shale, the sandstone in the central part softer, and more friable and contains specks of ferruginous matter..... 930′

Oneida (Levant) Sandstone..... 568′

6. Red and greenish gray, silicious breccia and conglomerate. 158′

5. Hard, massive, greenish sandstone and gray conglomerate. 410′

No. III.

Hudson River (Matinal) Shale..... 1870

4. Brown and bluish-gray shales and sandy slates, containing especially in upper part beds of argillaceous sandstone. A reddish-gray shale in upper portion contains crinoid stems... 800′ ±

Utica (Matinal) Slates.

3. Brown, brownish-gray and black fissile slate, parts very carbonaceous, toward lower part becomes slightly calcareous. 1070′ ∓

No. II.

Trenton (Matinal) Limestone.

2. Dark blue and bluish-gray, soft, argillaceous limestone, alternating with blue, calcareous shale particularly toward its upper limit..... 500′ (?)

Calciferous (Auroral) Magnesian Limestone.

1. Massive, light bluish-gray, magnesian limestone. Upper part only exposed, lower horizon below surface of erosion.... ——

No. I.

Potsdam Sandstone below the present surface.

NOTES *to explain the above Section.*

The Section, although a continuous one of Carboniferous, Devonian and Silurian strata, is subdivided into groups which represent the long since recognized and generally accepted formations of the State Geological Reports of New Jersey, Pennsylvania and New York.

The original numbering of these formations from I to XIII is the oldest attempt at a subdivision of the Palæozoic system, having been made in 1836. The numbers were used as a provisional nomenclature in publishing the Annual Reports of the First Survey of Pennsylvania. They have been used more or less in all subsequent surveys by geologists. They are retained in this section as convenient symbols for ready reference, although they have lost much of their lithological and still more of their palæontological value.

The geographical nomenclature of the New York Final Reports of 1843 and 1844, as well as the more poetical names afterwards adopted by Professor Rogers for his Geology of Pennsylvania, published in 1858, are given with the numbers, although the formations to which they have been assigned do not in all cases exactly correspond as to their upper and lower limits.

Some new names will also be noticed, chiefly near the top of the section. *Pottsville Conglomerate, Mauch Chunk Red Shale* and *Pocono Sandstone* are geographical synonyms for XII, XI and X,—or for *Seral, Umbral* and *Vespertine,*—proposed by the present State Geologist, to fill the gap at present existing in the *geographical nomenclature* of the Palæozoic rocks between the Catskill Formation and the Alleghany River Coal Measures. As IX and X together make up the mass of the Catskill Mountains, yet have always been regarded as separate formations, and as there is a geological objection to distinguishing them as Lower and Upper Catskill, the fact that X constitutes the mass of the Pocono Mountains in Pennsylvania, has been taken advantage of to provide it with an analogous geographical and euphonious name.

Mauch Chunk and Pottsville, where XI and XII have their maximum development, are important and well-known places, and there seems to be no valid objection to applying these names to those formations.

Much lower down in the Section a subdivision of the Lower Helderberg group, a limestone formation of unusual thickness, is named from the borough of Lewistown, one of the most important places on the Juniata River, where this limestone attains its maximum of size. A special name for the limestoue is called for, because it cannot yet be certainly identified with any special one member of the Lower Helderberg Series.

As to the thicknesses assigned to the divisions and subdivisions of the Section, it must be understood that they were obtained partly by direct

measurement of single outcrops, or series of outcrops,—partly by geometrical construction of a vertical section along one line, and by means of occasional, but neighboring outcrops,—and partly by construction on one or more lines of observation.

The planes or horizons between the groups and formations of the Section are in some cases arbitrarily assumed, being based exclusively neither upon lithological nor palæontological grounds, as the descriptive text of the section shows. In a number of instances the division or subdivision line has been necessarily drawn at the end of an exposure, or at a sudden break in, or change of, the topography.

The section must therefore be taken only for what it is worth, but by no means as a complete, authorative or final statement of the constitution of the Palæozoic system in Middle Pennsylvania. Many of its lacunæ will no doubt be filled up by future explorers, and some of its zero points shifted the better to agree with the true succession of deposits.

No. XIII. Alleghany River (Lower Productive) Coal Measures.

The Mahoning Sandstone at the top of the Section has commonly been considered the base rock of the Barren Measures, or Lower Barren Measures, of the great Bituminous Coal Field of Western Pennsylvania. But as it may with equal propriety be accounted the top rock of the Lower Productive Coal System (being in fact known as "The Top Rock" on Broad Top), and as the Alleghany River Coal Series must be taken (as Mr. Platt's report on Somerset Co. will show) to include the entire 800 feet of Coal Measures from the Pittsburgh Coal Bed down to the Pottsville Conglomerate (or even lower still), no mention of Barren Measures has been made in this Section.

The Mahoning Sandstone, No. 267 of the section, caps the hill to the north-west of Robertsdale in the East Broad Top or Trough Creek Coal Basin, where the top of the section ends. It is given a thickness of 90 feet; a portion of it may have been eroded from the surface of the hill.

The coal measures beneath it (Nos. 266 to 251 inclusive,) are 174 feet thick and consist of shales, slates and sandstones, containing 5 workable seams of coal (2 benches each). On account of a number of rolls in the strata and the varying dip of the rocks at Robertsdale, where the coals have been most extensively developed, and for the want of a system of levels throughout the workings on the coal seams, it was impossible, with any degree of certainty, to determine the precise intervals between the several coal beds. The given thicknesses between the coals are only approximate, and may be found to vary as much as 10 feet, although the total thickness of the series is probably as fair an estimate as can be made. If the classification which is proposed for the coal seams shall be verified by actual development, it gives us a means of comparison with the Alleghany series in Western Pennsylvania.

XII. *Pottsville (Seral) Conglomerate, (Millstone Grit).*

Upper member	(Piedmont sandstone) No. 250.....	160′	280′
Middle "	(Kanawha River series), Nos. 249, 48, 47, 46..	40′	
Lower "	(No. XII proper) Nos. 245 and 244.....	80′	

1. *The Upper member,* or (Piedmont sandstone) consists of three parts: upper white and reddish-white and gray, flaggy sandstone and conglomerate; in the middle part the conglomerate predominates, the pebbles here being the largest, but very irregularly distributed, while the strata themselves exhibit false bedding in a marked degree. The lower part of this member is composed, principally, of thinly bedded and conglomeritic sandstone.

The beds of conglomerate do not seem to be persistent. It would appear as if a bed, in force in one locality, feathers out from a centre of maximum thickness in all directions and disappears entirely, while an upper or lower conglomerate bed has its minimum thickness at the very locality where the other is at its thickest.

Dr. Newberry, in Vol. II, Geology of Ohio, p. 107, suggests the origin of the conglomerate in No. XII as being due to icebergs. He says, "From the similarity of the deposits now being made by icebergs, over various portions of the sea bottom, with those made by the same agency during the Drift Period, and of both to the materials composing the carboniferous conglomerate, I have suggested the possibility that they might all be products of the same agency. In this view the conglomerate should be compared with the kames and eskers of the drift. This theory, however, is not insisted upon, but is simply a suggestion, which has sprung from a conviction of the entire inadequacy of any other solution of the problem yet offered."

2. *The middle member,* or Kanawha River Coal Series, so named from its great development along the Kanawha River, in West Virginia, consists of sandstones and shales containing a seam of coal, No. 248, about 2 feet thick, which represents undoubtedly the Mount Savage coal bed. This set of beds resembles strongly in general character the rocks of the lower productive coal measures.

The coal bed No. 248 is overlaid by sandstone and shale No. 249, and underlaid by massive gray sandstone No. 247, exhibiting false bedding, with probably a bed of fireclay between the sandstone and coal. The seam was located in many places on Wray's Hill and Rocky Ridge, but there was only one locality (Rocky Ridge, west end of Wray's Hill tunnel) where its thickness could be determined and it was impossible on account of water in the opening to ascertain the exact nature of the underlying stratum.

No. 246 at the bottom of the middle member is 7 feet thick and (17 feet below the coal seam) is composed of dark gray and black slate and slaty sandstone; the slate predominating. A small seam of coal was reported to have been found in the black slate, but it is a little doubtful, as no traces

of its existence could be found, although some parts of the slate itself seem to be slightly carbonaceous. The whole member is quite argillaceous and contains a great deal of oxide of iron, which, on weathering, renders the surfaces of the strata of a dull brown color.

3. *The lower member*, or Conglomerate proper is for the upper ten feet composed of (No. 245) hard, massive, gray sandstone; the surfaces are very much coated with iron, and the layers contain a great many floral impressions (lepidodendra, calamites and sigillaria).

The remaining 70 feet of this member consists (in the upper part) of a hard, massive, gray and white sandstone and conglomerate, the latter predominating toward the central part, where the pebbles are larger. In the lower part there is less conglomerate, the sandstone becoming dark gray and flaggy and containing micaceous specks.

A careful study of the section reveals some very sharp horizons between sandstone, shale and slate, and coal and sandstone, conveying the idea of sudden and great changes of the conditions attending the deposit.

In Clinton county, in north central Pennsylvania, I have measured the conglomerate (probably lower member) and found it only 25 feet thick. To the south-west of Broad Top the series expands very rapidly, the expansion taking place in the middle member. At Pottsville No. XII is 1030′ thick.

On the Kanawha River, in Raleigh Co. West Virginia, Prof. W. M. Fontaine reports the following section (Silliman's Journal, April, 1876):

Upper conglomerate 150 to 200 feet thick.

Kanawha coal series (Fontaine's New River Series), composed of sandstones, shales and slates, containing nine seams of coal, whose aggregate thickness is 20 feet. The coals occur in the centre and toward the top of the series. Thickness 967 feet.

Lower conglomerate, thickness 80 feet.

The thickness of the upper and lower members at Broad Top and on the Kanawha River is the same, while the middle (coal-bearing strata) on the Kanawha is 24 times thicker than the same series at Broad Top.

A number of years ago Prof. Lesley reported on two workable beds of coal in Montgomery county, Virginia, and his discovery of more than a dozen coal beds along the western flank of Peak Mountain in Wythe County, in No. X. and named the coal series after the New River. This name, takes precedency of Prof. Fontaine's name of New River, applied in recent publications, to the Conglomerate coal series, of No. XII which Mr. Lesley therefore proposes to call the Kanawha River series.

No. XI. *Mauch Chunk (Umbral) red shale.*

Upper member	(shales and sandstones) 243 to 232.....	910′	1100′
Middle "	(mountain limestone) 231 to 221.....	49′	
Lower "	(shales and sandstones) 220 to 213.....	141′	

1. *The upper member* is made up of red shales and sandstones, with alternations of gray, flaggy sandstone and shale. Its upper limit is well-defined by a gray mottled carbonate of iron, No 243, which, along its out-crop has

been oxidized by the action of the atmosphere, and is changed from a proto-carbonate of iron into a brown peroxide.

In many places on Wray's Hill in Todd and Carbon Townships, the blossom of the ore bed, along its outcrop, is a silicious and shaly brown hematite, and on Iron Knob, directly to the south of Wray's Hill tunnel, loose fragments of the ore were found as a very silicious brown hematite associated with and containing pieces of red and green shale.

The lower limit of this upper member is placed on the red, shaly limestone of the middle member. The three-fold character of the upper member, which Professor William B. Rogers mentions as being everywhere discernible in Virginia, is to some extent to be noticed here, for we have the upper 209 feet formed of variegated and alternating red and gray sandstones and shale ; directly below this 524 feet of harder strata composed principally of gray and red sandstones, flags and shale, the upper part exhibitting false bedding ; while the 177 feet immediately above the limestone are made up of red shales and sandstones, the former predominating. We then have the following sub-divisions of this upper member :—*a*, from Nos. 243 to 239 inclusive ;—*b*, from 238 to 233 ;—*c*, 232.

The No. 242 seems to be a persistent associate of the overlying ore bed, it is extremely argillaceous and at times seems to be formed of clay. Small specks of carbonaceous matter were found scattered through the mass on the southeast flank of Wray's Hill near the road crossing to Cook's station.

No. 241 is, probably, more variable in character than 242. In some localities it seems to change into, or be replaced by, red shale, not being distinguishable from 240.

No. 240 and 239 are more like argillaceous marlites, easily weathering, and producing a deep red soil.

On account of the very imperfect exposure of this part of No. XI, the section may not reveal the minuter and more important alternations of the strata which doubtless exist.

Professor Rogers (Final Report, Vol. I, p. 531) says, "These strata become more silicious as they approach the Conglomerate, and in the form of green, buff and hard reddish argillaceous sandstones embrace impure calcareous beds." The relative position of these beds will appear from the following observations made on the west flank of Broad Top Mountain, half a mile below Riddlesburg.

(17.) No. XII, seral conglomerate not 100 feet thick, the lowest coal bed above it being only about 100 feet above the limestone No. 14.

(16.) Interval of a few feet unknown.

(15.) Silicious slate, dull brown color, 10 feet.

(14.) Limestone, hard, silicious, reddish, embracing plates of red shale ; its fragments strew a blank space of 40 feet, occupied probably by red shale below its apparent outcrop.

(13.) Sandstone, fine-grained, micaceous, green, passing downwards into olive shale, 20 feet.

(12.) Sandstone, gray, 3 feet (exposed).

(11.) Interval, 10 feet, probably red shale.

(10.) Sandstone, laminated, greenish-gray, micaceous, 3 feet (exposed).

(9.) Shale and fine, micaceous, argillaceous sandstone, 20 feet.

(8.) Sandstone, ferruginous, massive, close-grained.

(7.) Sandstone, coarse-grained, massive and distinct quartz grains in contact, apparently cemented by an oxide of iron resembling the Clinton Block ore near Beavertown, Union County. Thickness 3 feet.

(6.) Sandstone, rather massive, greenish, interstratified with green and red shales, 20 feet.

(5.) Sandstone, dirty green, pretty compact, becoming micaceous downwards, brown and very ferruginous, 13 feet.

(4.) Limestone, greenish, very silicious with pebbles and plates of green shale, hard and weathering with a worm-eaten aspect, 2 feet.

(3.) Sandstone, green, argillaceous, micaceous, laminated, 7 feet.

(2.) Interval, 45 feet.

(1.) Sandstone, light brown, micaceous, laminated: beneath the red shale at the river bank.

This section from the base of the Conglomerate No. XII down to the bottom of 2) shows a measured thickness of 196 feet, with two unmeasured intervals, (8) and (16.)

The whole aggregate thickness from the base of No. XII to the red shale at water level would probably be between 200 and 220 feet. The distance between the two sections at Wray's Hill and Riddlesburg is about 9 miles (air line). As the thickness of No. XI in that distance would probably not vary appreciably, the Riddlesburg section may be said to represent *a* of the upper member at Wray's Hill. The general character of the two is somewhat similar, the difference being no greater than might be expected when the circumstances under which the deposit was made are taken into consideration.

The coal seam, which is mentioned in (17) as occurring 100 feet above the limestone (14) is not, as reported above, in the "lower productive coals," but is an interconglomerate coal found between the upper and lower conglomerate members of No. XII, and probably identical with the coal bed No. 248 of our section.

b. This part is composed principally of gray and red sandstones, flags and shales, and is 520 ± feet thick. It is somewhat harder than the overlying mass and exhibits false bedding in the sandstones toward the top, as seen in Wray's Hill tunnel; the seams along the bedding containing calcite.

The strata here are not as argillaceous as those in the lower part of the member.

"*c.*" The lower subdivision is made up of very argillaceous shales and sandstones, easily weathered, forming a deep red-colored, clayey soil.

At Richmond Falls on the New River, W. Va., this series has a thickness of 1450 feet, distributed as follows: 3. Upper red and variegated

shales, 310 feet. 2. Middle gray and greenish sandstones, 820 feet. 1. Lower red shales and sandstones, 320 feet.

At Quinnimont on the Kanawha River, the transition layers between No. XI and No. XII are shown in the following section :

5. Black fissile slates and shales, 20 feet.....	210′
4. Thinly laminated, gray flags and calcareous shales containing in the upper part carbonaceous shales and strings of coal, 50 ft.	
3. Variegated marlites with some nodular limestones, 70 feet....	
2. Gray calcareous sandstone, 20 feet.....	
1. Bright red shales, seen 50 feet.....	

No coal was found in this series in Huntingdon County.

Prof. Wm. B. Rogers mentions a coal under the Conglomerate on little Sewell Mountain, which he queries equivalent to the Sharon Coal of Western Pennsylvania. He also notes the occurrence of a seam 4 feet thick in subdivision *b* west of Lewisburg, Greenbrier County, Va., and of two beds in Montgomery Co., one from 2 to 3½ feet thick, and the other from 6 to 9 feet thick composed principally of slate.

2. *The middle member* (Mountain Limestone) is made up of red and gray argillaceous limestone and red shale. The limestone and shale alternate so irregularly that it is hardly possible to distinguish any well-marked subdivisions. The whole thickness of this member is 49 feet, the correctness of which depends upon the identification of the variegated red and gray massive limestone No. 224 at New Grenada with that at the quarry worked by John Whitney, near Todd P. O.

The thickness of the series exposed at New Grenada is 35 ± feet. At the quarry worked by Whitney the highest limestone stratum exposed is No. 229, and the lowest No. 221, making 36 feet in all. But if the variegated red and gray limestone bed at New Grenada be the same as that near Todd P. O., then we neither found the lowest stratum at the former locality nor the highest at the latter ; but the lowest exposure at New Grenada is 14 feet above the bottom of the series, while the highest near Todd P. O. is 13 feet below the top. The possible error (in the event of the erroneous identification of limestone No. 224) is 13 feet, which would make the thickness 36 feet instead of 49.

An analysis of the section shows the following divisions :

Upper	Red limestone No 231.....	3′
	Red shale Nos. 229 and 230.....	15′
	Red limestone No. 228.....	2′6″
Middle	Red and gray calcareous shale Nos. 227 and 226.....	5′
Lower	Red and gray limestone Nos. 225, 224 and 223.....	13′
	Red shale No. 222.....	6′
	Gray limestone No. 221.....	4′

On account of the great variability of the limestone beds, the above can hardly be proposed as a distinct division characteristic of the series.

To bring the section into accord with observations made at other localities, in the bituminous region of the State, it might be well for convenience of comparison to divide the series into an *upper* and a *lower* limestone member, separated by a middle mass of shale, as indicated.

Where the limestone was studied in Smith's and Plank Cabin Valleys, the *upper* member is composed of more impure and argillaceous beds than the *lower*, and the only parts of the series which have as yet proved of any very great economical value, are the variegated red and gray limestone No. 224, and the more massive gray stratum No. 223, the latter by analysis containing 92.32 per cent. of carbonate of lime.

In two localities *fossil* remains were found in the *upper* member. In Well's Valley to the south of Broad Top Mountain, near Wishard's old saw mill, a bivalve shell and a coral were found (Roger's Vol. I page 530), and at the quarry near Todd P. O., in Plank Cabin Valley, the following genera and species were collected from stratum No. 228, *Grammysia*, *Strophodonta*, *Rhynchonella* and *Terabratula Rœmingeri*. In No. 226 a *Centronella* was disclosed. A close study of the outcrop in Plank Cabin Valley would no doubt result in the finding of other species.

Prof. Rogers (Vol. I, page 472) reports that this limestone series can be traced from the Conemaugh River along Chestnut and Laurel Ridges to the Southern boundary of the State.

"It occurs as a more or less silicious limestone, containing well rounded grains of sand of a light blue color, sometimes having a yellowish tint. The upper part is remarkably full of fossils as is also the central mass of shale."

The series seems to feather to the north on the Alleghany Mountain near the sources of the Conemaugh, gradually augmenting through the southern part of the State and Maryland until in Greenbrier Mountain, Pocahontas County, W. Va., it attains a thickness of 822 feet, known as the Lewisburg limestone. It ranges in force still further south through Eastern Tennessee and Northern Alabama to the end of the Appalachian coal belt in the latter State. In the west the mountain limestone is known as the St. Louis and Chester groups.

Prof. Fontaine (Silliman's Journal, Jan. 1877) proposes the mountain limestone for a base to the Umbral (Mauch Chunk) No. XI; first, on account of the physical character and composition of the red shales between the Vespertine (X) and the limestone; second, on account of the subordinate position which the limestone would otherwise occupy in the comparatively restricted Umbral Series.

There are several objections to this classification:

1st. Although the red shale which occurs under the Mountain Limestone undergoes a rapid and progressive attenuation to the west and south-west, the limestone itself is not found in the anthracite region where the Mauch Chunk series has its greatest development, and is a red shale formation

"par excellence," having a thickness of 3000 feet at Mauch Chunk on the Lehigh river.

2d. There is no marked distinction in physical aspect or composition between the lower and upper members of No. XI either in Western Pennsylvania, where the limestone is found, or in Eastern Pennsylvania, where it is entirely wanting.

3d. The topography produced by the upper member of No. X is so different from that produced by the red shale XI below the limestone as to suggest a classical distinction between the two.

The lower member is made up principally of red sandstones and shales; with alternations of coarse-grained, gray and greenish-gray, flaggy sandstones and shales; the latter predominating toward the bottom.

The lower member is devoid of all remains of fossil life, as is also the upper member.

In the layers transitional between the Umbral (XI) and Vespertine (X) occurs an iron ore bed of some local importance in Trough Creek basin. Its precise stratigraphical position was not determined; but it is probably not far above what we have considered as being the top of No. X.

This ore of XI has been developed to some extent at the old workings of the Trough Creek furnace, at the eastern base of Terrace Mountain. "Here the bed occurred in balls closely imbedded in a little earth and was of a number of varieties." (Rogers, Vol. I, page 529.) "Several of these varieties were of a common compact brown ore, seldom exhibiting any hematitic structure, but having a smooth jaspery surface and brittle fracture."

"The Hopewell ore-openings display the ore bed on both sides of the gap cut through Terrace Mountain by Yellow creek. A tunnel 90 feet long reached the ore on the south side of the gap 90 feet below its outcrop, the ore being from 20 inches to 3 feet thick, interposed between the sandstone below and the red shale above, and interstratified with more or less clay. The adjoining red shale lies in thick but very soft strata, is friable and of an intense red color directly below the ore. Thin layers of a more sandy ore are interleaved with the red shale."

The three horizons of economical importance are therefore:

1, that of the Ore bed directly under conglomerate No. XII;

2, that of the Mountain limestone;

3, that of the Ore bed directly above No. X.

No. X.

Pocono (Vespertine) Sandstone.

Upper member (massive and flaggy sandstone), Nos. 212, 211 and 210		610 feet.	
Middle member, 1. Coal bearing strata Nos. 209 to 158 inclusive, (New River series)	313	693 "	2133'
2. Conglomeritic strata, characterized by false bedding, Nos. 157 to 127 inclusive	380		
Lower member (sandstone and shale), (Nos. 126 to 117)		830 "	

The series might be more properly divided into four members ; but as the conglomerate beds and coal-bearing strata of the middle member are always found where coal beds have been discovered, the latter above the former, I have preferred to consider these two formations, which in themselves are so distinct, as constituting one member.

The upper member of the series is composed of coarse-grained, massive, brownish-gray and gray sandstone, alternating with thinly bedded and flaggy sandstones of the same color. Near the top there are a few beds of red shale and sandstone ; and towards the bottom there are beds of black slate containing floral impressions.

The transition of the shales and sandstones of the lower member of No. XI into this upper member of No. X is rather sudden. The bottom of No. XI is rather argillaceous, while the top of No. X is very silicious ; the sandstones in the former (XI) are fine-grained, thinly bedded and flaggy, while those in the latter (X) are coarse-grained, more massive, and recur with fewer alternations of shale than in the former case. The strata are thicker and the change from sandstone to shale less frequent. The upper member of X generally forms the flank of the ridge or mountain whose crest is formed by the lower part of the middle member. The eroded surface of the mountain being very nearly a plane surface, although sloping of course at a pretty high angle, it is seldom cut by streams running transversely to the strike, such as produce the gullies which are so characteristic of that flank of a mountain of Medina and Oneida (No. IV) formed by the Hudson shales ; in fact the drainage is generally effected solely by the stream at the base of the mountain, following it in a parallel direction

The topography of the lower member of No. XI is very marked and quite different from that just described. It generally presents itself as a chain or succession of little hills or knolls, containing the outcrop of the limestone beds of XI, and separated by depressions through which the small streams descending from the flank of the mountain of XII. break just before they join the main stream of the valley flowing along the foot of the mountain of X. In the district lying east of the Broad Top Mountain the place to look for the limestone beds is alongside of and close to the principal stream, which therefore flows along the eroded outcrops of the soft red shales *below* the limestone. This suggests a third reason why the top of the Pocono or Vespertine sandstone should not be considered the base of the mountain limestone.

The middle member of X is subdivided into :

1. Coal-bearing strata, New River series.
2. Conglomerate and conglomeritic sandstone, characterized by false bedding.

The coal-bearing strata contain 19 seams of coal, with an average individual thickness of one inch and a half. Their thickness, if added together and combined with that of the numerous thinner seams and partings

scattered through the strata, and not precisely located in the section, would be sufficient to form a solid seam of coal about four feet thick.

The following analysis of the section shows the position of each coal bed and the feet of interval between, formed generally of sandstone :

29 feet	5 inches.		Sandstone, Nos. 209 and 208,—at the top.
		2½″	Coal (seam No. 19), No. 207.
76 "	3	"	Sandstone, Nos. 206 to 202 inclusive.
		2″	Coal (seam No. 18), No. 201.
1 "	6¼	"	Sandstone, Nos. 200 and 199.
		3″	Coal (Seam No. 17), No. 198.
41 "	4	"	Sandstone, Nos. 197, 196 and 195.
		1″	Coal (seam No. 16), No, 194.
2 "	6	"	Sandstone, No. 193.
		1″	Coal (seam No. 15), No. 192.
	6	"	Sandy fireclay, No. 191.
		1″	Coal (seam No. 14), No. 190.
47 "	1	"	Sandstone, Nos. 189 to 186 inclusive.
		1″	Coal (seam No. 13), No. 185.
6 "	0		Sandstone, No. 184.
		3″	Coal (seam No. 12), No. 183.
6 "	0		Sandstone, No. 182.
		1″	Coal (seam No. 11), No. 181.
4 "	0		Sandstone, No 180.
		3″	Coal (seam No. 10), No. 179.
2 "	0		Sandstone, No. 178.
		1″	Coal (seam No. 9), No. 177.
1 "	0		Sandstone, No. 176.
		1 ′	Coal (seam No. 8), No. 175.
36 "	8	"	Sandstone, No. 174 and shale No. 173 directly above coal.
		1″	Coal (seam No. 7), No. 172.
	1	"	Fireclay, No. 171.
5 "	0		Sandstone, No. 170.
		1″	Coal (seam No. 6), No. 169.
	10	"	Sandstone, No. 168.
		2″	Coal (seam No. 5), 167.
	5	"	Sandstone, No. 166.
		2″	Coal (seam No. 4), No. 165.
17 "	0		Sandstone, Nos. 164 and 163.
		2″	Coal (seam No. 3), No. 162.
28 "	0		Sandstone, No. 161.
		1″	Coal (seam No. 2) No. 160.
5 "	0		Sandstone, 159.
		1″	Coal (seam No. 1), No. 158, at the bottom.

Fireclay occurs only under seams No. 7 and 15 ; that under No. 15, being very sandy.

The sandstone between the several seams has a great sameness of character, and is very much broken up by false bedding and fractures; in many cases it contains thin seams or partings of coal. The numbered seams and partings generally lie parallel with the true bedding of the strata, although in many instances *they are found along the planes of false bedding.* The thicknesses are very variable, in places increasing from 1 and 2 inches up to 10 inches and 1 foot; and sometimes a seam will be very much broken up and separated by a mass of sandstone, which splits the bed for some distance, but afterwards disappears, permitting the severed portions to unite again.

The almost total absence of fireclays under the coal seams, and the occurrence of coarse sandstone in many places directly above them seems to show that the coal has been derived from plants which may have grown at some distance from the locality and been afterwards floated and caught in the falling sediment, forming "drift beds." The period was undoubtedly one of continuous local current agitation as indicated by the coarseness and false bedding of the strata.

The lower part of the middle member is characterized more particularly by its beds of conglomerate and conglomeritic sandstone, both of which exhibit false bedding in a marked degree.

At the top of it directly under coal seam No. 1, comes No. 157 of the section, 25 feet thick, composed of soft black shale containing plates of coal and impressions of minute plants, alternating with a fine-grained conglomerate which contains micaceous specks. The surfaces of the shale are very much stained with iron. Directly below these alternating beds occur (No. 156) 26 feet of a yellowish-gray argillaceous shale also containing plates of coal and showing "slickensides," giving evidence of some contortion and slipping of the strata.

The first well defined and massive sandstone (No. 155 of the series) occurs below the shale; is 9 feet thick and is separated by 2 inches of black carbonaceous slate (No. 154) from 113 feet (Nos. 153, 152 and 151) of hard massive and conglomeritic sandstone, *showing a greater amount of false bedding than any other part of the section.* No. 152 contains a few alternating beds of black slate, but is *en masse* the hardest and most massive part of the Pocono or No. X epoch. It forms the crest of Sideling Hill, apparently throughout its whole extent; its position in the mountain can be seen both in Sideling Hill creek section and E. B. T. R. R. section accompanying the report of the Aughwick Valley. Below these harder and more massive strata there are 82′ 7″ (Nos. 150 to 144 inclusive) of shale, with a few beds of sandstone, the whole underlaid again by 25 feet of hard, massive sandstone (No. 143), and 13 feet (No. 142) of fine-grained conglomerate containing thin beds of black micaceous sandstone.

The general character of the section below this part is as follows:

Shale and sandstone (No. 141)	26 feet.
Massive sandstone showing false bedding (No. 140)	17 " 0

Shale and sandstone (Nos. 139 to 136 inclusive)	5 feet 9
Sandstone (Nos. 135, 134, 133)	17 " 10
Shale (Nos. 132 to 128 inclusive)	4 " 6
Sandstone and shale (No. 127)	15 " 0

The sandstone and conglomerate, throughout the whole series, seem to alternate with the beds of shale as shown in the following grouping :

Shale	51′	380′
Sandstone	122′	
Shale	83′	
Sandstone	38′	
Shale	26′	
Sandstone	40′	
Shale	5′	
Sandstone	15′	

Throughout the upper member of this Pocono or Vespertine Formation No. X, and the coal-bearing strata of the middle member, remains of a terrestrial vegetation are more or less abundant both in the sandstone, shale and slate. The following genera and species have been determined by Prof. Leo Lesquereux in specimens collected from the débris at the west end of Sideling Hill Tunnel :

1. *Sphenopteris flaccida* (Crépin), a new species for America but recently discovered in Belgium, stage of the *Psammites du Condroz*, which correspond to the upper part of the Catskill (IX) of Pennsylvania ; for the same formation has still a *Psilophyton* and *Palæopteris hybernica*.

2. A species of *Ulodendron* with scar leaves obsolete. It seems to be quite near to if not identical with *Ulodendron majus* (Sternb.), a species found in the sub-conglomerate coal of Alabama, but ascends to and above the Conglomerate.

3. *Knorria acicularis* Göpp, from the transition measures of Silesia. It is new for this country but passes by decortication to the following:

4. *Stigmaria minuta* Lesq. First Geological Report of Pennsylvania, Plate XVI, fig. 1 and 2, from the Pocono (Vespertine) of Mauch Chunk.

5. A branch referable to *Stigmatocanna Wolkmanniana* Göpp, but not positively ascertainable, the bark of the tubercles being destroyed.

6. A *Lepidodendron* (?) in four twisted and compressed fragments, so much deformed that the outlines of the scars are not discernible.

Nos. 1 and 4 are the more predominant species and are represented by many fragments.

"The specimens were very hard to study and determine, as they are twisted in many directions and the vegetable fragments covered with a coating of coal as hard as graphite."

3. The *lower member* in its general character bears some resemblance to the upper member in as far as it is made up of alternations of sandstones and shales.

The sandstones are more argillaceous and not as massive; they are coarse grained and stained with iron, and at times contain red and yellow specks.

The shales are both argillaceous and silicious, and the alternations with the sandstone are more frequent than in the upper member.

The predominating colors of the sandstone and shale are gray, yellow, olive and green.

This member seems to contain more ferruginous matter disseminated through the strata than either of the other members, and quite frequently iron concretions are found.

The horizon between the Pocono (X) and Catskill (IX) is not very distinctly marked. The greatest distinction between the two is that of color. The upper strata of the Catskill are more argillaceous than those at the bottom of the Pocono, which fact in a measure determines the topography of the two.

Prof. W. M. Fontaine, in Silliman's Journal for January and February, 1877, gives a description and section of the Vespertine (Pocono, X) in West Virginia.

In Lewis Tunnel through the Alleghany Mountain, on the Chesapeake and Ohio R. R., he has constructed the following section:

135 feet. Upper part (30 feet) dark shales, olive and reddish marlites, below which occurs 10 feet of firm thin bedded black shale holding a local coal 12 inches thick. The lower half is composed of firm, silicious, rather coarse bluish-gray sandstone holding bits of lower rocks, drifted stems and coal beds.

Below this mass come the coal-bearing strata 215 feet thick, distributed as follows:

15′.....Black sandy slates.
3′.....Sandstone.
6″ Coal, slaty.
5′.....Fireclay containing rootlets.
2″ Coal.
1′ Fireclay.
30′ .....Gray sandstone with films and streaks of coal (floated).
1′.....Black slate and coal.
3′.....Brown flaggy sandstone.
8″ Coal.
5″ Fireclay.
5′.....Bluish-black sandy shales.
50′.....Gray flags.
— Interval (?) feet thick.
20′.....Olive sandstone.
40′.....Argillaceous thickly bedded sandstone with thin films of coal and black shale.

Below this series occurs a white, pebbly, silicious sandstone, very persistent, at least 60 feet thick, the mass directly underneath being concealed.

From the base of this sandstone to the top of the red marls and sandstone (No. IX) there is a thickness of 500 feet, more or less, made up of flaggy sandstone with interstratifications of shales, all of which when fresh have a dingy yellow or brownish-gray color, but weathering to a dull brown.

Professor Fontaine seems to prefer calling the 60 feet at the base of the coal-bearing strata the base of No. X, but further states that the underlying 500 feet might perhaps be thrown into the Vespertine or Pocono Epoch. Judging from Fontaine's descriptions, to bring the section in harmony with the East Broad Top, I think it would be necessary to consider the lower 500 feet as included, making a total thickness for No. X of 910 feet, more or less, which would then be represented by 2133 feet at Broad Top, reversing the relationship in the two localities between No. XI and No. XII, both of which are thicker in the Virginia section than at Broad Top.

The general sections of Prof. Fontaine's, given in the text, I have compiled from his elaborately detailed descriptions in Silliman's Journals, to which the reader is referred.

No. IX.

Catskill (Ponent or Old Red) Sandstone.

Thickness (Nos. 116 to 108 inclusive), 2680 feet.

Character: consists for the most part of thick alternating red argillaceous shale and sandstone, and occasional beds of gray, yellow, white and green sandstone and shale. On account of its uniform composition it does not admit of sub-division either by its fossils or mineral composition. Unlike the groups of Nos. X, XI and XII, which gradually assume new phases, this series, undergoes no important modification other than that of thickness throughout the State.

The *upper* part of No. IX is composed of red shale and sandstone alternating with gray and whitish sandstone, containing micaceous specks. The *central* part seems to be made up principally of red flaggy sandstone and shale alternating with thin massive yellow, gray and white shaly sandstone; toward the bottom the red shale becomes more sandy, contains less alternations of gray shale and a number of imperfect remains of what apparently was a terrestial vegetation, the accumulation in some localities being sufficient to form small "drift beds" of coal. The *lower* part seems to contain a predominant amount of ferruginous matter, and the surfaces of the strata are sometimes slightly stained with a bituminous coating. No fossils were found in this mass other than a few remains of fish bones and scales, having a white and bluish tint in contrast with the red and brownish-red shale. The strata throughout the whole formation are very argillaceous, weathering very easily, which fact is beautifully illustrated in the deep cuttings made recently in Smith's Valley, on the line of the E. B. T. R. R.

Prof. Hall gives the following description of it as studied by him in Eastern New York:

"The Old Red Sandstone, where fully developed, consists of various

strata of sandstone, shale and shaly sandstone, conglomerates and impure limestones. The pervading color of the sandy parts is brick red, though often lighter, and sometimes of a deeper color, from a larger proportion of iron; while the coarser parts are often gray and the shales are green. Beds of green shaly sandstone are interstratified with the red friable sandstone, and these are succeeded by a compact kind of conglomerate rock."

The following section of the Red Catskill is given by Prof. Fontaine (Silliman's Journal, January, 1877), constructed near Lewis Tunnel on the Chesapeake and Ohio R. R., W. Va.:

No. 3,	150′ ±	Red marl and sandstone, containing more sandstone than No. 2.	340′
No. 2,	70′	Dark red marlites with ochreous and very argillaceous sandstones. Balls and nests of limonite and decomposed pyrites.	
No. 1,	120′	Deep red marlites alternating with thick bedded and argillaceous reddish-brown sandstones in about equal proportions. These are underlaid by coarse sandstones containing Chemung fossils.	

No. IX is between 1,000 and 2,000 feet thick where it outcrops south of the anthracite coal fields, and on the south flank of the Catskill Mountains in New York. In the northern counties of Pennsylvania and in the north flank of the Catskill Mountains (N. Y.) it is probably between 400 and 600 feet thick.

This Formation forms the mass of the Catskill Mountains of New York, and the middle flank of the Pocono Mountains on the Pennsylvania side of the Delaware River. After passing the Lehigh River, its strata assume a vertical attitude, and the outcrop of its harder parts makes the southern of the two crests of the Second Mountain nearly to the Susquehanna River. Wherever the dip approaches 45° the red Catskill sandstones of IX form a bold terrace on the flank of the mountain, the crest being made by the Pocono sandstone of X, as in Peter's Mountain, at the mouth of the Juniata. Along the face of the Alleghany Mountain, this terrace of IX is cut up into a series of buttresses projecting from the escarpment. Around Broad Top the same *terrace structure* has given occasion for the name Terrace Mountain, which is merely the prolongation (in a curve backward) of the Sideling Hill which our Section crosses.

The formation contains in the Broad Top country no stratum of any economical importance. An iron ore bed occurs about 400 feet below the upper horizon. Its thickness is undetermined, and it was merely located from its outcropping on the north-west side of Smith's Valley, where it occurred as a very silicious brown hematite. It will probably never prove to be a workable bed.

Transition strata between the Catskill and Chemung epochs:

Thickness (Nos. 107 to 96 inclusive) 90 feet.

Character: Consists of yellow, red, green and olive shale and sandstone.

The surfaces of some of the sandstone strata contain a fine exhibition of ripple marks and impressions of fucoids and characteristic Chemung fossils, *Spirifer disjuncta, Rhynchonella,* &c.

Thirteen feet from the bottom occurs a brown ferruginous sandstone, No. 101, weathering readily on the surfaces from the oxidation of the iron, the representative of the Larry's Creek ore, which has a continuous range through parts of Lycoming, Clinton and Tioga counties. It attains its maximum thickness on Larry's Creek in Lycoming County, where the principal bed is 3 feet thick. In some localities it resembles closely the Cleveland ore of Yorkshire, England. In this portion of the State the bed is not workable.

No. VIII.

Chemung (Vergent) shales.

Thickness (Nos. 95 to 85 inclusive), 1860 feet.....

Portage (Vergent) flags. } = 3310′

Thickness (Nos. 84 to 71 inclusive), 1450 feet.....

The limits of the Chemung and Portage taken together are well defined, the upper being topped by the transition strata at the base of the red Catskill, and the lower by the olive slaty and shaly sandstone of the Hamilton period. The horizon between the two epochs is not as well defined and it has been located rather arbitrarily. There are certain large distinctions between the two which it may be well to notice before describing each in detail.

Both are made up of alternations of shales and sandstones. In the Chemung the strata are more silicious, while in the Portage they are more argillaceous. In the latter the sandstone is always finer grained and the shale more clayey than in the former. The Portage sandstones are flaggy and at times very shaly, and their alternations with the shale are very frequent, although the individual strata are quite thin, the shale predominating. The sandstones of the Chemung are more massive, occur in thicker strata, their alternations with the shale are less frequent and they seem to contain more ferruginous matter, and more micaceous specks. The Chemung strata, particularly the shaly sandstones toward the top, are replete with marine mollusca, particularly brachiopods, while the Portage is extremely poor in fossil life, with the exception of crinoid stems and sea weeds, or fucoids; although the occurrence of fossil fucoids would not distinguish the epoch, since they are also very abundant in the upper part of the Chemung, but possibly the two are of different types.

The *upper part of the Chemung* is composed of olive-brown and gray massive and sometimes argillaceous sandstone alternating with flaggy sandstone, and red and green shale, both shale and sandstone containing ferruginous specks.

The *central portion* of the epoch is made up principally of brown, red and gray sandstone and shale: the sandstone is probably more massive than

it is in the upper part, and besides ferruginous matter contains micaceous specks.

In the *lower part* the general character of the strata is very much the same, although apparently containing less iron and mica than the central part.

In descending from the top to the bottom of the epoch the sandstone which in the upper part seems to predominate, diminishes, while the shale increases, and the alternations of the two are greater, although of course the sandstone strata must be thinner. The upper part contains the greatest number of remains of fossil life.

The *general character of the Portage* seems the same throughout. The upper part is composed of rather massive brown and gray sandstone alternating with beds of olive and gray shale from 10 to 30 feet thick. Toward the centre the sandstone becomes more flaggy and occurs in thinner strata, while the shale becomes more argillaceous, forms thicker beds and is more varied in color. As we approach the lower horizon the sandstones become thinly laminated and occur in beds but a few inches thick; the shale is extremely argillaceous and weathers readily into clay. The shale, throughout the whole epoch, contains more or less iron, which on exposure readily washes out and is oxydized on the surface, coloring the shale in various shades of yellow, brown and red.

In New York, Prof. Hall reports (1843) that "the upper part of the Chemung is characterized by a general tendency to conglomerate, or gravel. In a few localities the mass becomes a well characterized pudding-stone. This conglomerate (continues Mr. Hall) nowhere attaining sufficient thickness or importance to merit a distinct description."

It is worthy of notice that this conglomerate, which forms several notable "rock cities" in South-western New York and which, probably, is the northern extension of one of the sands of the oil group of Western Pennsylvania, seems to be without even a representative at Broad Top. Although the sandstones toward the top of the Chemung are massive and coarse grained, yet there seems to be no tendency to conglomerate or gravel.

Again, cross lamination, or oblique, or current bedding, ripple marks, concretions and limestone strata which are so abundant in the Chemung and Portage Epochs in New York, are wanting in Central Pennsylvania. The ripple marks in a measure are an exception to this assertion, although they are comparatively rare, and though sometimes met with, they would not be difficult to overlook, especially after studying the fine exposures in the transition layers between No. VIII and No. IX along the E. B. T. R. R., those in the lower Catskill in Smith's Valley, and again in the bottom of the Hamilton on the Aughwick near Potts's Gap.

The absence of the limestone or limy shale and concretions may be attributed to the limited remains of marine life. These in New York are found in great colonies. Not only do we not find any limestone or limy shale, but the whole period is particularly devoid of any calcareous matter

in the cementing material of the sediment. This is readily shown by the rapid weathering of not only the shale but also the harder sandstone strata in the cuts along the E. B. T. R. R.

Professor Rogers (Final Report Vol. I, page 141) says of the Chemung: "This formation, remarkable for its general uniformity of composition, appears to have its maximum development in the region of the Juniata near Huntingdon, half way across the Appalachian chain, where its thickness is 3200 feet." Without reference to its thickness and character in other localities our measurement of its thickness (1950 feet) near Huntingdon seems to show that the above generalization is hardly well founded.

The Chemung formation makes both ridges and valleys. The upper part forms a ridge parallel to the mountain of X. The valleys are generally narrow and sharp, for the most part running parallel with the strike.

Portage rocks make also ridges and valleys, the ridges not as prominent as in the Chemung, and the valleys and ravines more irregular, not having such a great tendency to be parallel with the strike of the rocks.

The mass contains no strata of economical importance. Some of the sandstones are quarried to a limited extent for building stone. The sandstones and conglomerates forming the "oil sands" of north-western Pennsylvania, which are perhaps cotemporaneous with the Chemung Epoch, have no representative at Broad Top.

Genesee (Cadent Upper) Slate.

Thickness: (Nos. 70 to 67 inclusive) 325 feet.

Character: Consists of olive, slaty and shaly sandstone alternating with brownish-gray flaggy sandstone and dark olive shale; toward the lower part the sandstone strata disappear, and the shale becomes more argillaceous, until finally at the bottom we have dark olive fissile slate with occasional seams of a bright brown-colored sandstone from 2 to 4 inches thick. The shale and slate are slightly bituminous and stained with iron.

These rocks form valleys and are of no economical importance.

Hamilton (Cadent) Shale.

Thickness: (Nos. 66 to 63 inclusive) 635 feet.

Character: Consists in the *upper part* of gray sandstone flags and shales; toward the central part the sandstones predominate in a three-fold character of massive, flaggy and slaty, to the exclusion of the shale. Surfaces of the sandstones are stained with iron and contain the following fossils: *Aviculopecten princeps, Chonetes mucronatus* and *Chonetes coronata, Grammysia, Spirifer granulifera, Spirifer mucronatus, Tentaculites,* and *Algæ,* more particularly *Spirophyton caudagalli.*

In the *lower part* the sandstone is not so massive, being more flaggy and shaly; the flaggy sandstone at times becoming quite calcareous, and is very much stained with iron. Shale alternates with sandstone, and toward the bottom predominates, being of a gray and dark olive color, sometimes thinly laminated and fissile.

Along the Aughwick creek near Potts's Gap in the lower strata there is a fine exhibition of ripple marks.

These rocks make ridges and in the Aughwick Valley are not of economical importance; in New York the Hamilton contains a number of very fine flagstone quarries.

Marcellus (Cadent Lower) black slate.

Upper member	(Nos. 62, 61 and 60)	571 feet.	875′
Middle "	(No. 59)	20 "	
Lower "	(Nos. 58, 57 and 56)	284 "	

This formation might be more properly divided into an upper and lower portion as the lithological characters of each are quite distinct; what we have called the middle member may prove to be but locally deposited.

The *upper member* consists of brown, gray, olive and black argillaceous shale with occasional seams of flaggy and slightly calcareous sandstone in the upper part, and seams of non-calcareous sandstone in the lower part. The sandstone and shale, but more particularly the latter, are very much stained with iron and bituminous matter.

The *middle member* is made up of shaly argillaceous limestones, alternating with greenish-gray lime shale. The exact position of this member of the series may be a little above or below that given in the section. The only place where it seemed possible to study this portion was in the valley of Blacklog Creek, near Orbisonia, where the dip of the strata was rather uncertain, and too far from the section line to make its position certain. Although it has been thought best to suggest only a local deposit of this limestone, economically considered, yet it seems quite certain that the horizon may not be more calcareous in one locali y than in another, but, on account of the associated strata being very argillaceous, the carbonate of lime may be more generally disseminated in one place than in another; in the former case producing nothing but a calcareo-argillaceous shale, and in the latter case an argillaceous limestone.

The *lower member* consists of black fissile slate and black and brown shale, the surfaces of both being very much stained with iron and coated with bituminous matter. In this lower member in the valley of the Juniata, above and below Lewistown, occur irregular deposits or beds of coal, the vestiges of a vegetation which appears to have been air breathing or terrestrial. The lower horizon of the series is marked by an important ore bed No. 56 which primarily is a proto-carbonate of iron but which has been changed at its outcrop by atmospheric action into a brown peroxide of iron.

It is not an infrequent thing to find the black shale and slate of the lower member very much contorted and dipping in an opposite direction to the general lay of the strata. These transverse dips are seldom of any extent and if relied upon lead to errors in constructing a section. It seems probable that some of the faults which have been located in the Marcellus and

associate strata may have been based upon observed dips in the lower member.

The epoch is valley making and has three horizons of more or less economical importance.

The *Marcellus iron ore* bed is of great importance from the Juniata River to the Maryland State line and supports a large iron industry. It varies in thickness from 3 and 4 up to 10 feet, occurring as a series of solid gray layers separated by thin seams of slate. In its native proto-carbonate condition it is a bluish-gray or lead colored ore, sometimes massive, breaking into square pieces, and at other times of a slaty or laminated structure. Where the ore has not been thoroughly subjected to atmospheric action the change to brown peroxide is only partial, a solid nucleus forming the interior of the lump, while the peroxide occurs on the surface as a crust of greater or less thickness.

The following are two partial analyses made by Mr. A. S. McCreath, Chemist of the survey, of ores from the end of Jack's Mountain :

	Fleck's bank.	McCarthy's bank.
Iron	46.5	39.100
Manganese	——	.201
Sulphur	trace	.430
Phosphorus	.133	.060
Insoluble residue	17.120	——

Upper Helderburg or Corniferous Limestone (*Post Meridian*).

Thickness : Three Springs and Saltillo (Nos. 55 to 47 inclusive), 60 feet.

Character : Consists of dark blue and gray argillaceous limestone alternating with green, olive and gray calcareous shale. Prof. Rogers, in the first report, says : "That the post meridian series may scarcely be called a Pennsylvania deposit as it only enters the eastern borders of the State near the Delaware Water Gap." He includes the calcareous beds which have been placed in the section as Upper Helderberg in the Marcellus Epoch ; but as the limestone strata seem to be very generally distributed through the centre of the State and as they must owe their origin to dynamical conditions entirely different from those existing during the black slate deposition above, from which they differ so widely lithologically it seems more reasonable to consider the limestone as representative of the New York Upper Helderberg until the division can be established palæontologically, or on other than purely lithological grounds.

These rocks form one flank of the ridge made by the Oriskany. Some of the more massive limestone strata are quarried, the stone on being burned making a poor lean lime. In some places the formation contains a rather poor argillaceous carbonate of iron (ore bed). The Hawk Mine, worked by the Rockhill Iron and Coal Co. north of Orbisonia, is located on this bed, which appears to be a local deposit.

The petroleum of Canada, according to Prof. T. S. Hunt, is indigenous to this formation.

No. VII. *Oriskany (Meridian) Sandstone.*

At Three Springs, Nos. 45, 44 and 43.....	Thickness.....	58	feet.
At Orbisonia.....	"	150 ±	"

The *upper part* is composed of a coarse-grained ferruginous and calcareous sandstone containing a great deal of iron toward the top, and is surmounted by a bed of ochreous clay.

The *central portion* is made up of a loose, friable sandstone containing pebbles the size of a pea, larger than any found in the upper or lower parts.

The *lower part* consists of a coarse-grained, arenaceous sandstone more fragile than any toward the top of the mass, and breaking into more irregular shapes. The sandstone contains a great deal of ferruginous matter and the surfaces are at times coated with peroxide of iron.

The epoch contains the following fossils: *Cyrtoceras expansus, Dalmania micrurus, Eatonia peculiaris, Megambonia lamellosa, Orthis hipparionyx, Platyceras ventricosa, Pterinea texilis, Rensselæria marylandica, Rensselæria ovalis, Rensselæria ovoides, Spirifer arenosus* and *Spirifer arrectus.*

The species of marine life found in the lower Helderberg limestone seems to have been cut off by the changes which ushered in the Oriskany Epoch, a group of fossils peculiar to it assuming their place. Most of the fossils are remains of mollusks, no vertebrates or remains of land plants have yet been found. So far Palæontology seems to assign a distinct place to the Oriskany between the Silurian and Devonian ages. Viewing the dynamical conditions attending the deposition of the Devonian age Dr. Newberry places the Oriskany at its base; and says: "The Devonian rocks of Ohio form a circle of deposits, which records an invasion of the land by the sea, and presents in its series of strata, a history of the successive stages of that invasion; first, the mechanical sediment of the Oriskany; then the Corniferous limestone, the deposit of the open sea; then mixed mechanical and organic materials; the mechanical sediments finally predominating and indicating a return to land conditions over all the eastern portion of the continent."

The epoch is ridge making, and has three horizons of economical importance:

1st. Upper ore bed, occurring at the upper limit of the sandstone. This bed is seldom workable in Pennsylvania, but is very productive in the valley of the James river, Virginia. In many localities the mass consists merely of the upper strata of the sandstone strongly impregnated with peroxide of iron.

2d. In the Juniata Valley where the Oriskany is friable and contains little or no iron, it affords a valuable sand for glass manufacture.

3d. Lower ore bed, occurring at the junction of the coarser and more arenaceous strata at the bottom of the sandstone with the soft, calcareous yellow layers beneath it. This bed is worked by the Rockhill Iron and Coal Company near Orbisonia and in Hill Valley.

No. VI. *Lewistown (Pre-meridian—Lower Helderberg,) Limestone.*

Thickness: (Nos. 42 to 38 inclusive) 162 feet.

Character: Consists of massive, dark blue and gray, semi-crystalline limestone, containing toward the upper and lower parts alternating layers of gray shaly limestone and argillaceous lime shale. To the north-east in the Juniata Valley from Mount Union to Lewistown, the shale at the top of the mass becomes a thicker and more distinctive formation. There are fine exposures of the series along the Kisicoquillas creek, near Lewistown, Mifflin County, where it was found necessary to give it a new geographical name in the failure to identify it with any of the sub-divisions of the lower Helderberg group in New York.

The following fossils have been determined: *Acervularia, Alveolites minima, Astylospongia inornata, Merista lævis, Orthis oblata, Pentamerus galeatus, Rhynchonella formosa, Astylospongia, Atrypa reticularis, Aulopora, Conophyllum, Merista arcuata, Stromatopora, Trematospira formosa,* and *Zaphrentis.*

This formation with the Oriskany is ridge making, and of great economical importance, as it furnishes good lime for building and agricultural purposes, besides being an excellent flux in the iron furnace. A specimen from Saltillo contained: Carbonate of lime 90.904; carbonate of magnesia 2.162.

An iron ore having a laminated structure occurs sometimes scattered in the soil overlying the limestone.

Water-lime (Scalent) Cement Beds.

Thickness: (Nos. 37 to 28 inclusive) 580 feet.

Character: Consists for the most part of a blue and gray flaggy and thinly bedded limestone having a wavy stratification. Toward the top the limestone is massive, slightly argillaceous and of a dark gray and bluish-gray color; but toward the bottom it becomes flaggy, thinly laminated and shaly, having a brownish-gray and yellow color. In the lower part limestone alternates with green, yellow and gray argillaceous shale.

The strata in the central part contain a great deal of calcite, and the surfaces of the stone are oftentimes coated with carbonaceous matter, and show "slickensides." The limestone beds are frequently highly magnesian, and a few may be compared economically with the Lewistown limestone. The outcrops occupy a small valley at the foot of the Oriskany ridge

Onondaga (Scalent) Marls.

		Saltillo and Three Springs.	Orbisonia.
Thickness:	Upper member Nos. 27, 26 and 25.....	170 ± feet.	145 feet.
"	Lower " " 24, 23 " 22.....	270 ± "	230 "

The upper member consists of yellow, gray and greenish shaly and argillaceous (fossiliferous) limestone in thin beds, alternating with olive, green and gray calcareous shale.

The lower member consists of green, yellow and gray calcareous shale,

alternating with red shale and containing occasional beds of fossiliferous, shaly limestone.

The Salina group thins in this district to the south-east, being thicker on the Jacks Mountain range than it is along Blacklog Mountain. It makes a valley and is of no economical value.

Niagara Limestone.

The Niagara limestone seems to be without a representative in Pennsylvania.

In a section which was constructed through Jacks Mountain at Mount Union, a limestone bed 3 feet thick was located 232 feet above the top of the Clinton red shale, which was supposed to be the representative of the Niagara limestone; the intervening space between this and the Clinton being filled with a soft, argillaceous, calcareous shale. The occurrence of the Niagara limestone here, as well as at Logan Gap 25 miles to the north-east, where a similar bed 4 feet thick was found, is extremely doubtful. A careful search for its representative at Rockhill Gap in Blacklog Mountain, and on each side of the Jacks Mountain anticlinal at Three Springs, and Saltillo, failed to bring it to light. It is questionable in the author's mind whether the Niagara measures which form such a marked feature in the geology of northern New York has in this section of Pennsylvania a distinct representative. While this epoch seems to be vacant in our palæozoic column, the Salina rocks, which occur directly above the Niagara, seem to be totally different in character from the New York strata, where they are composed of shales, marls and marly sandstones with impure limestone; ours being almost entirely destitute of fossils. Is it not possible that the strata which are included between the bottom of the Water lime shale and the top of the Clinton red shale represent equally or conjointly the Salina and Niagara groups of New York?

No. V. *Clinton (Surgent) Shales.*

		Saltillo.	Orbisonia.
1. Red shale (Nos. 21, 20 and 19).....	Thickness	270 feet.	233 feet.
2. Upper olive shale (Nos. 18 to 15 inclusive)	"	162 "	163 "
3. Ore sandstone and fossil ore (Nos. 14 to 11)	"	42 "	54 ± "
4. Lower olive shale (Nos. 10 and 9).....	"	— "	660 "

1. The upper part of the red shale consists of silicious massive red shale having a rhombohedral fracture. Toward the lower part the red shale becomes more argillaceous and contains thin alternations of gray and green calcareous shale, while at the bottom there are beds of red shaly sandstone having seams of calcite running through the mass.

2. The Upper olive shale consists of yellow, olive and gray calcareous shale containing seams of blue fossiliferous limestone; the lower part forming the hanging wall of the fossil ore beds is composed of a light yellow argillaceous lime shale.

3. The fossil iron ore beds occurring above the ore sandstone have been extensively developed in Rockhill Gap by the Rockhill Iron and Coal Co.

Beside seams Nos. 12 and 14 of the section there are two other small beds below the ore sandstone. The first, from 4 to 6 inches thick, occurs directly under the sandstone and about 50 feet below the upper beds (C. Constable). The second is 10 inches thick and about 4 feet below the first. These two beds have never been worked. The beds above the sandstone are worked on the south side of Rockhill Gap by two drifts 100 feet vertically apart and having an average course of S. 21° W. The same beds are worked also on the north side of the Gap by two drifts which are about 60 feet vertically apart, the strike being about the same as on the south side. The course of the south drifts when continued across the Gap to the north side strikes about 100 feet to the west of the north openings, the ore range being thrown to the east on the north side by a fault which runs through the Gap at right angles to the strike. In gangway No. 1 on the south side the yield of a specimen was as follows :

	No. 14.	No. 12.
Iron	50.800 per cent.	50.700
Sulphur	trace.	trace.
Phosphorus	.112	.123

The ore sandstone has a thickness of 42 feet at Saltillo and of 50 feet at Orbisonia.

The sandstone varies very much in character in the different localities, as to the amount of calcareous matter which it contains ; at Rockhill Gap it is very silicious, while at Saltillo it is quite calcareous. In the latter locality the ore beds seem to be represented by a calcareous sandstone containing a large percentage of iron, but not a true iron ore.

The sandstone generally forms a terrace along the flank of the mountain of No. IV.

4. Lower olive shale (Nos. 9 and 10).—Thickness : 660 feet.—For description see section

The following fossils were found in the Clinton Epoch, more particularly in the upper olive shale : *Atrypa reticularis, Beyrichia lata, Buthotrephis gracilis, Dalmania limulurus, Homalonotus delphinocephalus, Orthis elegantula, Platyostoma niagarensis, Pterinea emacerata, Rhynchonella neglecta* and *Strophomena rhomboidalis.*

No. IV. *Medina* (*Levant*) *Sandstone,*

White sandstone, No. 8	Thickness 400 feet.	1330′
Red sandstone and shale, No. 7	" 930 "	

The white sandstone contains in New York several characteristic fossils, some of which the marine plants, and more particularly the *Arthrophycus harlani,* are found throughout its whole range from Pennsylvania to the south border of Tennessee.

The red sandstone and shale member is in Pennsylvania entirely destitute of fossils, and is a coarser and more sandy rock, than in New York, where it is composed principally of a finely-comminuted red marl or a calcareous red clay, containing a few organic remains.

A deposit of iron ore exists in the white Medina forming the crest of Blacklog mountain 4 miles south-west of Orbisonia. The ore and clay in which it lies seem to fill a transverse fissure or cleft in the white sandstone, at a point where there is a slight indentation in the crest of the mountain.

Oneida (Levant) Sandstone.

Upper member, red and greenish-gray silicious breccia and conglomerate, No. 6, thickness 158 feet.....	568′
Lower member, hard massive, greenish gray sandstone and conglomerate, No. 5, thickness 410 feet.....	

A striking feature of the epoch is its poverty in organic remains.

The Medina and Oneida rocks taken together make "all the mountain ridges and higher spurs of the entire chain west of the Susquehanna, between the Kittaning valley and the valley at the base of the Alleghany mountain," except those surrounding the Broad Top synclinal basin.

No. III. *Hudson River (Matinal) shale.*

Thickness: (No. 4) 800 feet.

Utica (Matinal) slate.

Thickness: (No. 3) 1070 feet.

The upper limit of No. III is well defined by the rapid and sudden transition of the Oneida gray sandstone and conglomerate into the argillaceous sandstone at the top of the Hudson River slates. The lower limit has been assumed at a very lean, poor shaly brown hematite ore, which seems to occur at the horizon between the shale and slate of the Utica and the blue calcareous shale at the top of the Trenton or Matinal limestone mass. The division between the Hudson and Utica was not positively determined, and may possibly be above or below the position which has been given it. Unconformability has been asserted to exist between the Hudson and Oneida.

Prof. Rogers speaks of it as follows: "The relations of the Matinal series to the overlying Levant strata * * * plainly show that * * * the earth's crust experienced a prodigious movement at the close of the Hudson period. This agitation of the floor of the sea, which had just received the materials of the Hudson shales, appears to have been everywhere attended by an extensive displacement of its level, accompanied in some districts by undulations amounting even to a close plication or corrugation of its sediment, and in some districts to a lifting up of wide areas above the general sea level into dry land."

The slates of No. III make one flank of the mountain of No. IV, and contain no strata of economical value in this district.

No. II. *Trenton (Matinal) limestone.*

Thickness: (No. 2) 500 ± feet.

The thickness of the epoch is only approximately determined from a

very limited observation in Blacklog valley. A very distinct palæontological break exists between this epoch and the underlying auroral magnesian limestone, the upper strata of which are exposed in the centre of Blacklog Valley opposite Rockhill Gap. It is probable that the Magnesian rocks in this part of Pennsylvania are at least 3000 feet thick, which would place the top of the Potsdam sandstone (the lowest group in the Palæozoic column), at least three quarters of a mile vertically beneath the present surface of the centre of Blacklog Valley.

LOCALITIES WHERE THE STRATA WERE MEASURED AND STUDIED.

No. XIII.

Nos. 267, 266, 260, 256 and 252. Robertsdale, Trough Creek coal basin, Carbon Township.

Nos. 265 to 261 inclusive. Coal bed D (Lower Freeport ?) Section measured about 400′ from mouth of mine C¹, Robertsdale collieries.

Since the section was compiled, I have been informed by Mr. Wm. A. Ingham, President Rockhill Iron and Coal Co., that a bed of black band ore has been discovered in the "Swamps" in mine C′, between the bottom bench of coal and the fireclay floor, ranging from 1 to 4 inches thick and yielding 30.79 per cent. of metallic iron.

Nos. 259, 258 and 257. Coal bed C (Kittanning ?) Section measured about 200′ from mouth of mine B¹, Robertsdale collieries.

Nos. 255, 254 and 253. Coal bed B (Clarion ?) Section measured by Wm. Foster, Esq. in mine A, Robertsdale collieries.

No. 251. Coal bed A (Brookville?) Section reported by Wm. Foster, Esq. "Monkey drift," Robertsdale collieries.

No. XII.

No. 250 to 244 inclusive. Rocky Ridge near Wray's Hill Tunnel, Todd Township and Wray's Hill, Carbon Township.

No. XI.

Nos. 243, 242, 241 and 240. Wray's Hill and Rocky Ridge.

No. 239 to 234 inclusive. Wray's Hill Tunnel E. B. T. R. R.

Nos. 233 and 232. Ground Hog and Plank Cabin Valleys, Carbon Township.

Nos. 231 and 230. New Grenada, Taylor Township, Fulton County.

No. 229 to 220 inclusive. Limestone quarry worked by John Whitney, Esq., near Todd P. O., Plank Cabin Valley.

No. 219. Ground Hog and Plank Cabin Valleys.

No. 218 to 213 inclusive. Well on Ezra Heater's farm, one mile south of Todd P. O., section reported by Mr. Chas. E. Billin.

No. X.

No. 212. Ground Hog and Plank Cabin Valleys.

No 211 to 124 inclusive. Sideling Hill Tunnel E. B. T. R. R.

No. 123 to 117 inclusive. Smith's Valley. Clay, Cass and Union Townships.

The total thickness of No. X was verified by measurements made in Sideling Hill Gap, Fulton County.

No. IX.

Nos. 116, 115, and 114, Smith's Valley.

No. 113, J. B. Moreland's farm, Smith's Valley near Sideling Hill Tunnel.

No. 112 to 108 inclusive. Smith's Valley, along line of E. B. T. R. R. and Sideling Hill Creek. Deposits of "drift coal" in No. 109 found on Wm. Smith's farm, 1½ miles from Mapleton, Union Township.

No. 107 to 96 inclusive. Transition strata. R. R. cut end of Clear Ridge, north-west of Saltillo, Clay Township.

No. VIII.

No. 95 to 85 inclusive. Line of E. B. T. R. R., north-west of Saltillo and Sideling Hill Creek, Clay Township, and Coaling Ridge, Cromwell Township.

No. 84 to 71 inclusive. Line of E. B. T. R. R., north-west of Saltillo, and north-east of Three Springs, Clay, Springfield and Cromwell Townships.

No. 70 to 67 inclusive. Sideling Hill Creek and line of E. B. T. R. R. north-west of Saltillo, Clay Township and north-east of Three Springs, Springfield and Cromwell Townships.

No. 66 to 63 inclusive. North-west of Saltillo, Clay Township and Saddleback Ridge, Springfield and Cromwell Townships.

Nos. 62, 61, 60, 58, 57, and 56. North-west of Saltillo, north-east of Three Springs and Aughwick Valley near Orbisonia.

No. 59. Quarry near I. Engeart's house, 1 mile from Orbisonia.

No. 55 to 47 inclusive. R. R. cut at Three Springs.

No. VII.

Nos. 45, 44 and 43, R. R. cut at Three Springs. Fossils were found on end of Royer and Sandy Ridges near Orbisonia.

No. VI.

No. 42 to 38 inclusive. Near Three Springs, Saltillo and Orbisonia; fossils found at latter locality.

Nos. 37, 36 and from 34 to 28 inclusive. Near Saltillo. Three Springs and Orbisonia.

No. 35, Rockhill Furnace water-lime quarry near Orbisonia.

No. 27 to 22 inclusive. Near Saltillo and Three Springs.

No. V.

Nos. 21, 20 and 19. Near Saltillo and Three Springs.

No. 18 to 15 inclusive. Near Saltillo and in Rockhill Gap, Cromwell Township. Fossils found at Rockhill Gap.

Nos. 14, 13 and 12. South fossil ore mine, Rockhill Gap.

No. 11, Rockill Gap and opposite Leas and McVitty's tannery at Saltillo.

No. 10 and 9, Rockhill Gap.

No. IV and III.

No. 8 to 3 inclusive. Rockhill Gap.

No. II.

No. 2 and 1, Blacklog Valley, Cromwell Township.

Coahuila.

By Thomas L. Kane.

(*Read before the American Philosophical Society, January* 19, 1877.)

I. GEOGRAPHICAL.

I have recently returned from a three months' excursion into Northern Mexico. I went by rail to near San Antonio, Texas; from there took my own and government servants' wagons and mule teams. I was in no hurry, carried a party of intelligent friends with me as observers, and enjoyed advantages for seeing the country and its people which do not commonly fall to the lot of travelers.

I spent most of my time in Coahuila and Nuevo Leon. After visiting the country north-west of Piedras Negras, I looked up the different passes of the Sierra Madre which appeared inviting for railroad purposes from below Santa Rosa to La Rinconada. Finding Saltillo closely invested by Treviño, I crossed from the Saltillo road to Monterey, and thence returned to San Antonio via Mier and Laredo. I expect to have time soon to prepare a geographical paper and maps for the Transactions of the Society. I shall ask their patience this evening for the communication of a few facts not undeserving their notice.

I have drawn upon the blackboard, upon an enlarged scale, the leading features of Colton's latest Map of Mexico. I would ask your attention first to the contrast presented by the Rio Bravo to the other rivers of Southern Texas and Mexico. These are all greatly less conspicuous. They are seen to flow but short distances from their sources to the Gulf of Mexico. The Bravo or Grande del Norte, on the other hand, cuts a more important figure on the map, outdoing, apparently, the others put together. It is of much greater length and volume, and the reason is obvious.

By the contour lines, where you observe my effort to make hatchings with the yellow chalk, I indicate in a general way the course of the high land which is customarily spoken of as the East Branch of the Sierra Madre. From San Luis Potosi, here, (A) I have drawn the so-called Sierra as extending to the edge of the plain watered by the Rio Grande (B). It sinks as it proceeds north, until here, you see, only one mass of mountain north of Santa Rosa, I have represented it as entirely disappearing.

We have here our explanation of the greatness of the only Mexican great river, the Rio Grande. The great river, you remark, rises in the interior, more than half way across the continent, and it flows all this way as many as 1800 miles, to the Gulf; because no mountain obstacle is offered to its progress. It finds what might be regarded as a vast Pass where the "Sierra" has gone under. It is true (this is a parenthesis for our Secretary) that here (a) it is deflected, and, obedient to local geological orders, turns nearly at right angles, and works along at disadvantage for some distance, until it hits this seeming continuation of the valley of the Pecos (b). But it is

soon observed endeavoring to resume its direct forthright, and before long is found in line with itself, so to speak, adopting the course of the valley of the Salado (c d). The Salado, I will also halt to point out, runs parallel to a certain line of heights which has been recommended as the natural boundary line between the United States and the North-east Provinces of Mexico (C D).

Reflecting on the significance of such a fact as the Rio Grande, you perceive how natural a thing it was for me to ask myself: Why should not a new route for a transcontinental rail way be discovered here—not far from the path of the great water way—through upper Mexico? This led me to examine, as I have said, the different passes or depressions of the misnamed Sierra, furnishing inclines leading up to the elevation of the Great Table. I looked for them into or through the Sierra, it is true, but comparatively near the river, where its elevation is diminished, and what is left of it is broken up. I am rewarded by having found two, and probably three, Passes, preferable to those heretofore recommended to the Engineer.

I am positive now that I can indicate the true line for the railroad, south of the Union Pacific, from the United States to the Pacific Ocean; and the best of it is that the short cut, B F, is the one which provides the most moderate gradients. From San Antonio, as your starting point, make your shortest cut for Mazatlan, and you will not be very far from either of these two lines.

The routes described in this paper both pass through the rich agricultural Laguna country, and through the richer Durango mining one, and are both singularly cheap of construction. Neither of them is deflected noticeably from the straight line, except as the Pacific is approached, where, to avoid engineering obstacles (less expensive ones, though, than those which the California Central R. R. has overcome), I recommend turning down into the State of Jalisco, through the northern part of the District of Tepic. There the Sierra Nevada, E F, coming from the north west, lowers as the East Branch of the Sierra Madre does in Northern Coahuila. To obtain a gentle slope without paying for it, I do not attack, but flank the Snowy Range.

Next in interest to these inter-oceanic railroad data (perhaps, too, after certain military questions unavoidably associated with the same) I should, perhaps, advert to the results of a visit to the country below the upper bend of the Rio Bravo, marked on the maps as Terreno Desconocido and Territorio Non Explorado. I thought it would be a rare field for original exploration, but it proved to have been well known to the Spaniards, who have left roads, military earthworks, mineral shafts, and other evidences of their presence there. The names of old Spanish settlements might be sprinkled over all this unoccupied space (x to y, and v to z). The correction of such an error as this should appear at least in our children's school atlases. I could occupy the evening in enumerating others, but will close with citing two hardly less striking. The *Bolson de Mapimi*, here, which covers so large a space on the maps, should properly be restricted to a

more limited area, north of the town of Mapimi. Mapimi, an old Spanish mining town, gives its name to a mountain near it, shaped somewhat like a big purse (Hispanicè *Bolson*). It appears to have been an after thought with geographers to lay down a figure of this shape, large enough to include a great reach of desert* plain. A similar correction should be made for the *Barrial de la Paila,* which is quite a narrow stretch of sterile plain lying on the west side of the *Sierra* de la Paila.

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II. ETHNOLOGICAL.

After a review of Humboldt's work in New Spain, closing with a eulogium on the great Explorer's thoroughness, General Kane proceeded :

But Alexander von Humboldt did not visit the Northern Provinces of Mexico. And I may say another thing without irreverence ; he was not an ethnologist. In Spanish America, too, the persons who gave him most information in Natural History were priests or members of religious orders in the Roman Catholic Church. The minds of sincere persons in that communion have ever been fettered by the dogma that " God hath made of one blood all the nations of the earth," and they have seldom pursued ethnological research with zeal, never with impartiality.

I am sure that I do not overrate the value of Northern Mexico as a field for ethnological study. I can say emphatically of it that in this respect it is terreno desconocido ; territoric non explorado.

It will be particularly interesting to us to seek the solution there of certain Historical Problems which have baffled our investigations.

In the Old World we have not been able to divest ourselves of the bias arising from our being in some manner or other parties to the discussion of historical questions. Each specimen of us belongs to some particular race or mixture of races, and, whether he has had a grandfather or not to take a pride in, if his self-consciousness but carries him back a single generation, he unites in feeling with those whom he thinks most like himself in mistaking what they accept as History for Science. Most of us in fact have a direct political or religious interest or feeling involved in our preference for deciding questions by the bulletin or historical pamphlet, rather than by the scalpel and craniological caliper. Prejudice should blind us less in Mexico. If we love our Dutch or Scotch, and hate our ancestral Spanish enemies, we cannot help unduly praising our Orange-Nassaus, and hating our Alvas ; while we do not care enough to cheat much regarding the respective merits of the followers of Coanocotzin† or Ixtlilxochitl‡. An imputation on the standing of the Trinity, or the Virgin of the Immaculate Conception, may wound our feelings ; we care nothing for theories ascribing greater or less exaltation to the gods Texcatlipoco,§ or Cu-at-li-cu-e.‖

In Northern Mexico, races have lived of the greatest variety of osteological structure. They have left, and they are now depositing in profusion,

* *Desierto*, Desert, not necessarily meaning uninhabitable desert.
† Texcocan enemy of Cortès. ‡ Texcocan friend of Cortès.
§ Of Heaven ‖ Of Flowers.

most interesting crania, simple and composite. Nowhere probably in the world are so great a number of healthy, full-grown youths, of known habitat and pedigree, meeting with violent deaths, and leaving their bones at the command of the collector.

Over Northern Mexico, and through it, in times bygone, have passed successive migrations of races, as remarkable as those which have occurred in our own historical period in Asia and in Europe.

And, alas, of the conquest of the weak by the strong, of that which you and I, Mr. President, if alone, must maintain to be the *Survival of the Unfittest*, of the conquest of peaceful, industrious and civilized races by warlike ones, Mexico affords us at least two distinct and notable examples. Not less than two great invasions have proceeded directly from Northern Mexico, or passed through it. All the American conquerors of Central Mexico that we know of came from the North. We can study them in Northern Mexico as they existed before they removed South. It is an important point I make, that our researches in Mexico may be conducted in a strictly scientific spirit, free from the disturbing influences of partisan literature.—Of what nation is not the literature without force, if its tone is not (regarded in a philosophical sense)—provincial and partisan?

Again, the singularly favorable political anarchy now prevailing in Northern Mexico should be of the greatest service to the student. Seventy years ago the Spaniards governed New Spain. Not only their military sway (though, as I have intimated, it surprises the traveler every day how far out into the North they carried their military roads, their presidios, soldiers and cannon), but the dominion also of their laws prevailed, and their social customs, with their language and religion. Since the removal of the forces which maintained law and order, the whole of this régime has ended, or is coming to an end. The mental and moral characteristics of each native stock are seen to be re-asserting themselves. You can detect, with corresponding physiological varieties of structure, what manners the several species, sub species and varieties were originally prone to, what laws naturally suited them, what religion. In truth, straight out before your face, and inconveniently to the purpose if you are in their way, they disclose what other species of men they are predestined to hate, and refuse most ferociously to live with on terms of amity.

To a certain extent an invading movement from the North upon more Southern Mexico is going on at this moment. I had a peculiarly favorable opportunity for witnessing an instance of its operation on a small scale.

I obtained an invitation at Piedras Negras to accompany the column of Government troops which moved upon Monclova and San Buenaventura in November last, and I made the most of my good fortune.

I had Don Pedro Valdès, the Military Governor of the district of the Rio Grande, and Colonel Ferdinand Montragon, his second in command, with me all the way. As far as Monclova my mess, my tent, my ambulance were theirs; one or other of them hardly left my sight. They knew personally a large number of their soldiers; whenever any one attracted my

attention as a subject of study, and they could not answer my questions regarding his name, birthplace and genealogy, they ordered him up to speak for himself. They became honestly interested in some of my ethnological guesses, which they esteemed shrewd, and, I honestly believe, went beyond politeness in giving extension to my inquiries. I think I pretty faithfully studied over 300 equestrian men ; nearly all who were not of native Indian blood being Mestizo. Should I not at some future day recur to this subject, let me dispose of it by saying that, with traces of nearly every race whose abode has been the Iberian Peninsula, Basque, Jew, Zingaro even, the predominant Spanish element apparently was Andalusian. I could not at all guess how many kinds of native Mexican entered into the medley. My companions could distinguish many more than I could. A captain from near Bustamente, where there is an interesting ancient colony of them, could point out every Tlascalan in the crowd. But this I did see plainly myself, a large majority of the fighting *riders* were of the stamp of our own South-western warlike Indians. I am very familiar with the physiognomical characteristics of the Arrapahoe, Kickapoo (Qu. chica puta ?), Ute and Sonora Apache. I lived some time among the Shoshones, and may be trusted to detect the Comanche wherever it occurs. I found the Comanche through Valdès' command in force.

The small-sized photographs which I place on the table were selected by me, chiefly from an army officer's collection, as being striking likenesses of men termed Mexicans, and regularly enrolled as members of Valdès' National Guard. If they were dressed up in the pictures as Christians, I have no doubt the subjects and their friends would have great pleasure in recognizing them. On the face of each photograph you will find the Indian name and tribe, on the back the Mexican.

The other photographs support views advanced by me in former, now nearly forgotten, communications.* The notes endorsed upon them will I think repay perusal.

a. Affords an interesting example of Atavism: the *back leap*, as the Spanish term it. The mother, a Mexican woman whose family style themselves Spanish, acknowledging only one sixteenth of Indian blood, is convicted of the Sambo or Chino by its reappearance in her daughter, an engaging and estimable young lady who is quite a dark mulatto. Fig 1. Her sisters, 2, 4, 5, 6 exhaust the shades of the segar box.

b. and c. Exemplify strikingly the persistence of the type. The German girls in b. were captives from their youth, very hardly used up to the age of puberty, when they were rescued. c. was more tenderly nurtured, being a head chief's favorite daughter. They are tame ; she remains wild —*fera naturæ.*

*On Rank and Merit depending on lineage among certain (North American) Indian Tribes. 1847.

Lavater + Daguerre. 1848. Replies to Nott and Gliddon. 1850–1852.

Differences in the Results of Emancipation in the British West Indies corresponding to differences of Race observed there. 1853.

Idiosyncrasies of the Lucumis Gangas and other Bozales in Cuba. 1857.

The Application of Ethno-Physiognomy made by Mr. H. H. Slatter. 1856.

d. A family of German descent, exposed as partly Chino Mexican. The bony framework of the subjects not having been modified; the physiognomy, due to the integuments, is common to all the children, but the elder sister's face 2 is darkened by a shade of pigment in the mucous coat. In 1. and 4. it is said to be detectable in the *luna*.

The working of our little Invasion was about this: Valdès' army was made up, certainly more than half of it, of men of Northern Indian blood. They were moving south. Some of them might return, perhaps not many. When the company of Saragossa was marched off from that place, I saw a crowd of their women assembled to weep and wail over them in half Indian style, as if it were about to prove their last farewell. Other recruits who had left the pueblo under similar auspices had not returned. Their fate had been to die in battle, or of disease, or of the effects of wounds and exposure—or to embrace permanently the military career, in which case the élite of them found employment as regulars in the City of Mexico, or elsewhere in the provinces not far from the National Capital. The average man thus, after directly killing or contributing by impoverishment to starve a given number of the more industrious and peaceable members of races of the South, would become a southern resident, and leave descendants of his own, South, who would be half Northern and half Southern; that is, it might be, half warlike and lazy, half industrious and inoffensive.

Esteeming it a compliment to have been invited to express my opinions upon the political condition of Mexico at this interesting juncture, I will not consider it beneath the dignity of Science to notice the subject from an Ethnological point of view.

The North, as well as the rest of Mexico, presents a clearly marked case of Arrested National Development. The natural tendency of the different populations of Mexico to unite in one having been interfered with three centuries and a half ago by an outside pressure, and this pressure having been withdrawn, its effect upon the national life is now seen to have been unfavorable. Not only the political health, but, to persevere in the use of my figure, the existence itself of Mexico as a nation is menaced. The thoughtful observer is left in doubt whether, for the welfare of the people of Mexico, a synthetic or a further analytic treatment of their confederacy is most demanded. The former may be premature, the latter, now going on so rapidly, risks being carried too far. Many honest thinkers are of opinion that it would be beneficent to restore the foreign pressure, or an equivalent for it. In my opinion it would be but a reproduction of the original evil.

With your indulgence I will enlarge upon this theme, for brevity and to avoid confusion soliciting you to restrict the application of my remarks of a general nature to the Central Table Lands, of which we may popularly speak with least inaccuracy as Mexico.

At the epoch when the Wars of the Roses, Welsh wars and Scotch wars were preparing for Great Britain a United England; when the various elements already united as Gascons, Bretons, Picards, Normans were con-

tending which should form the future France ; when, — less effectually as it has proved, because the ethnological differences involved were greater, — the different populations of Spain and Aragon, Murcia and Granada were fighting out whether they should absorb or be absorbed in the kingdoms of Castile and Leon, the different native tribes of Mexico were at the same work in their own way.

They were very numerous. Geiger says, "There were at the time of the conquest and there are now, more than thirty different races, speaking as many different languages and marked by distinctive peculiarities." (p. 317.)

Our standard authority Humboldt's remarks are, "The great variety of languages still spoken in the Kingdom of Mexico proves a great variety of races and origin. The number of these languages exceeds twenty, of which fourteen have grammars and dictionaries tolerably complete. * * * It appears that the most part of these languages, far from being dialects of the same (as some authors have falsely advanced), are at least as different from one another as the Greek and the German, or the French and the Polish."

Humboldt mentions the Mexican, Otomite, Tarasco, Zapoteco, Misteco, Maya, Totonac, Popolouc, Matlazing, Huastec, Mixed, Caquiquel, Tarau-mar, Tepehuan and Cora. To these, the Mazahua, Huave, Serrano, — and, well, say a dozen others may safely be added. How many of these are derived from the primitive Nahuatl, neither this, nor in fact any other abstruse philological question, am I qualified to discuss. Enough here that my own observations lead me to place the number of separate tribal societies very high. But at the date of the Spanish conquest they were in a fair way of coalescing. With various ins and outs, and ups and downs, there can be no doubt that a process of consolidation was going on in Mexico through the thirteenth, fourteenth and fifteenth centuries, corresponding to that observable in Europe during the same period.

The Toltecans evidently had absorbed many tribes before they were succeeded by the Chichimecas, whose own absorptions constituted the monarchy of Tezcuco. Tacuba or Tlacopan had a similar history. So had the Aztec Kingdom or Empire, with whose history we are perhaps most familiar, the one ruled by the Montezumas. The original Aztecan divisions of Tlaltelolcos and Tenuchcas are mentioned to the traveler at this day, when his guide points out the ground they severally occupied upon the site of the present city of Mexico. These only united to form the Mexican monarchy in 1438. But by the beginning of the sixteenth century, Tlacopan, Tezcoco and Aztecan Mexico were practically united in one Confederacy. I cannot see how there is any room for question that the League had become a single nation, powerful enough to absorb all minor ones—outside of the Tarascos, and those Guastecos, who in Tamaulipas, under Cortina, are giving Texas so much trouble at this time. There survived, it is true, a few small independent nationalities. There was the priestly government of Cholula, and the moderately warlike kingdom of Aculhuacan, and the

Republic of Huexotzingo, and the stronger Republic of Tlascala, which was fighting for its independence against overpowering odds, when Cortez arrived barely in time to save it. Mr. Prescott has no authority for saying that the more widely the Aztec Empire was extended, the weaker it became. On the contrary, Mexico, under Montezuma II was as much a homogeneous nation between the Atlantic and Pacific for ten degrees of latitude, as Spain was then from the Mediterranean to the Pyrenees; more than England was from the Channel to the Highlands of Scotland.

I like to use dates when I can. In Europe we have 1519 as the year of the accession of Charles V in Germany. Three years before, the Fleming had become King of Spain. Four years before, Francis the First had become King of France. Ten years before, Henry the Eighth had ascended the throne of England. But in the spring of 1519 Hernando Cortez wooed his Malinche Marina in Tabasco and sailed with her to Vera Cruz. He entered the City of Mexico a conqueror, August 13, 1521.

With the effect of the European element introduced by Cortez you are familiar. The complete disintegration of all indigenous national combinations went with the extension over the Grand Mesa of the Spanish arms, laws, religious and social usages. We may safely speak of the Spanish rule as having continued absolute for more than two hundred years.

When, towards the close of the last century, the ethnological differences prevailing in Spain asserted themselves anarchically there, surprise is expressed at the slowness which her colonists evinced in throwing off the yoke. It was an uphill business in Mexico, and was managed there in the old time Spanish way—by men almost exclusively of Spanish blood. Their movement was not apprehended by themselves to be anarchical. They, at least thought that their cause was that of order, union and religion.

Hidalgo was a Spanish curate. Take his date as 1810 He was caught (where I came near coming to grief myself) at Bajan, in Coahuila, March the 21st, 1811, and shot the following 1st of August.

Matamoros, the curate of Jantetelco, was shot August the 3d, 1814, Curate Morelos, December 21st, 1815, and Mina, November 11, 1817. Yturbide proclaimed the Plan of Iguala February 14, 1821, and concluded the Tratados de Cordoba with Don Juan O'Donoju, September 27, 1821. Everyone of these champions of independence except Morelos, was clear Spanish, and the cry of the triumphant liberating army of the Three Guarantees I believe faithfully expressed the feeling of what was then still subsisting a Mexican Nation. The motto was borne on the tri-colored flag which the nation united in adopting. It was "Religion, Union and Independence."

Naturally we Americans have a prejudice against Yturbide because he had himself crowned Emperor in a cathedral, and perhaps because his family lived among us in their adversity, making themselves too familiar with us, particularly here in Philadelphia. But there was prob-

ably a good deal in Don Agustin before his head was turned. He had some excellent and faithful men, too ; and under him, or some of these, his nation, I think, might have hammered its music out. In my judgment, the Mexicans have always acted foolishly in imitating ourselves and the French. Their establishment of a Federal Government, October 4, 1824, with a constitution affecting to be more or less a copy of our own inconsistent binate one, was a mistake. But in the end, under it, or something like it, they could possibly have made things work. But they have never had a fair chance. Their country was too rich to be let alone.

Before they could set their first government in running order, foreign invasion, and threats of foreign invasion, compelled them to pay exclusive attention to their foreign instead of their domestic affairs. It threw into the background men of learning and men of moral worth, and brought forward the more brutal sort—the *hombres de armas*—men of the horse and of the sword—the curses of Mexico. These men were required to defend the people from those who should have given them common interests, but only gave them a common enemy.

Indulge me, if you please, in a little more chronology.

The gravest of Mexican errors, the expulsion of the Gachupinas, was brought on directly by the threat of Spanish invasion.

Not a year after the last Spanish troops embarked from Vera Cruz, November 18, 1825, the Padre Arenas conspiracy was under weigh.

Barradas' expedition actually landed in 1829.

Our colonization of Texas, under Stephen Austin, had begun early in 1828. Edwards' effort at revolution came off there, if I remember, the year before.

In 1832 our Texans united with Santa Anna in pronouncing against the government of Bustamante, and defeated the Mexican troops with loss. In 1833 they separated from Coahuila.

In 1835 and 1836 they—I had better say *we*—fought the Mexicans in Texas. We—our Government—formally acknowledged Texan independence in 1837.

1840 is the date of Ben McCulloch's Texan Ranger fight.

1841, 1842, 1843 are the dates of our expeditions against Santa Fe and Mier.

In 1844 President Tyler concluded his Treaty of Annexation with the Texan Commissioners. We admitted Texas into the Union December 27, 1845 ; fought our battles south of the Rio Grande in 1846–1847 ; patched up our so-called peace in 1848.

We were hardly done with the Mexicans then before the French were at them a second time with their *Reclamacion de los Pasteles*—"their Pie Claims," as the Mexicans call them. I omitted to mention that in 1837, at the time when we acknowledged the independence of Texas, France was bullying Mexico about these Pasteles—claiming damages for pastry-cook's trays and the like, to the tune of $600,000. In 1838 she had shown us, with a fleet of eleven vessels, how easy it was to humble Mexican national

pride, by taking the old fortress of San Juan d'Ulloa. How France went on after this, giving the Mexicans no peace, is the history so familiar to us of the famous Intervention.

The Mexicans had France, Spain and England together upon their backs by 1861. Bazaine did not evacuate Mexico till 1867.

Certain political wounds are too green for me to say what I think of the course adopted by the United States after this.

I am unfortunate enough to entertain the conviction that in morals we are responsible for a great deal of the wrong which has been done. Breaking off abruptly, I should beg you to pardon my apparently meaningless digression. I am not confident that I have made out my case, but I felt bound to put in a plea for my Mexican friends who appear to you inexcusably engaged in the business of national suicide.

So very few of our good men have ever met them, the Mexican good men and gentlemen, when the Erinnides were not pursuing them! I stand almost alone in declaring that I know them as uniformly courteous, and generous, and brave—worthy to be the sons of mothers who, rich and poor, gentle and simple, afford the world some of its fairest examples of devoted tenderness and saintly piety.—Admit that they seem to be given over to the Furies. If they deserve our censure, they are entitled to our pity.

This said, I will return to what I think indisputably true. The history of Mexico for the last half century is that of the resolution of a population more and more into its constituent elements. The different races have asserted themselves, or have been used by the various politicians to enforce their pretensions. Some of these fellows have been strongly backed, perhaps by the remnant of a former ancient confederacy or union of several tribes having similar ethnological characteristics ; others have appealed only to the interests of single tribes or half tribes, as insignificant as the following of the ten-vote repeater who traffics for office on our State House Row. The same phenomenon, the thought occurs to one, is seen in every country, but it looks uglier where it is associated with the direct employment of physical force. Running up from Acupulco, in 1857, I saw "the Southern Tiger" Alvarez. A straight-limbed old Indian—not a trace of Spanish was discernible in him or any of the squaws decked in French dresses who constituted his dusky harem. King of Guerrero his flatterers called him. Before the Conquest he would probably have been King of Michoacan. He might then have fought a Moctezuma. In our times he fought and overcame a Santa Anna.

Alvarez would have been at either epoch neither more nor less than Head Chief of Tarascos.

I will take a second example from the other extremity of the Republic. Tamaulipas on the Gulf of Mexico is another renowned nursery and cradle of Revolutions. It is a unit in politics. If a Mejia has it, he is as sure of his following as a Bayard in a southern county of Delaware. Only, its warriors do not turn out to vote. They follow him with horses and arms, and expect him to supply them with ammunition. Tamaulipas is popu-

larly spoken of as a State. It is regularly divided into three districts—del Norte, del Centre, del Sur—and sends its nominal representatives often to the Federal Capital. But it is nothing more nor less than the old country of the Guastecos, which was imperfectly subdued, even by the Spaniards in their day. And Tamaulipas too has its Head Chief now, a Major General, and Lieutenant General, and Excellency, Governor Supreme, and so forth—Cortina. And Cortina is all and singular, gold lace and epaulettes included, just about the blood thirstiest savage existing on the Continent.

What have we to study in Mexico ethnologically, besides the descendants of the primitive inhabitants? The Gachupinas? They are better studied in the land of their derivation. What else then for the study of the ethnologist in Mexico? Alas! The Mixtures. Nowhere is there presented a greater variety of these than in Mexico. Every proportion of every variety of Spaniard; with every proportion of Indian, Mediterranean man, Moor and Negro. Nothing can be more distasteful to the inquirer who desires a simple study, than the variety of mental and moral characteristics which we find in the Mestizoes is associated with their diversity of physical constitution.

Among the mixed breeds the difference in the proportion of the characteristics derived from the different ancestors introduces anarchy into social circles, into the family itself. The appetites, the passions, the powers, the higher aspirations of one child are impatient of, are directly hostile to those which contribute in a different proportion to form the character of another. Here then, among the people of mixed breed is the Debatable Ground, the field for the intrigues and machinations of the designing politician. The typical politician of Mexico is himself the result of a mixture. He is restless, because the different elements in him vary his desires and aspirations. They are not the same at different periods of his life, are modified by the company he is keeping. He is inconsistent, when the medium in which he lives undergoes change. He lies, perhaps for the same reason that he is inconsistent. He is deliberately perfidious even, and then is the last man on earth to know how little he is to blame for being so. Who is to blame for his ferocity combined with gentleness, for his mingled generosity and ravin, his instincts of high honor united with deceit; yes, with revolting treachery. The answer is, the man who is responsible for his being the mixed man that he is; the Spaniard who was his ancestor is the culprit, who basely mated with the Indian woman from whom the Indian part of him is derived.

We have a distinguished Professor of Princeton proposed for membership to-night, whose ripe scholarship the Society will doubtless honor with the tribute of an election. There are members of the Society on the floor before me who believe (and they are entitled to their belief, though it is not my own) that there is an *Ultimate Philosophy* which will harmonize all knowledge with Religion. Indeed, I know that there is one, my valued friend, who goes so far as to entertain the conviction that Theology is entitled to be

ranked among the Exact Sciences. To such I would turn, and, adopting the terminology of that imposing study, would indicate the value of Northern Coahuila as a Hell where we can study faithfully what Sin means. We need be at no loss there for examples, for proofs that the sins of the fathers are visited upon the children—and that, beyond the third and fourth generations.

The splendid conqueror still dazzles our eyes as he flashes across the page of history. We realize how *chiquard* it seemed to many a young Spanish noble of pure blood to follow in the footsteps of Hernando Cortez, to carry about or be carried about by, to lead or be led astray by his Malinche—but we have come down to the end of that nice business. The dreadful end! The savage Indian would not now be re-asserting his savage characteristics, but for the aid lent him by the Devil working through the illegitimate descendant of the Spaniard. There is no mistaking it; it is the Red Savage—the old Adam—*terra rubra* there, out upon the warpath. The Spanish military rule first overthrown, he has subverted the civil order which it sustained. For the law which the Spanish introduced (a stately system not unworthy of its Latin origin) he prefers, perhaps on the way to re-introduce ancient barbarous and local usages, the momentary will of the last chief under whom he has fought as a brave (bravo) in battle. The language, for the birthright to use which all Christendom envies the Spaniard, he is expelling from the country by debasing it more and more with his native Indian below standard. Finally, he is destroying the last bond which holds the peoples south of the United States together, their religion. Under Juarez, who faithfully merited his surname of El Indio, and his successor, Lerdo, the persecution of the Catholic Church has been successful in eradicating true religious feeling to an extent which, before my last visit, I could hardly have believed possible. Among the ruling politicians in the north, I did not meet one man who, in conversation with me, did not proclaim himself superior to "Superstition." The authorized school books, in the miserable attempts at public schools, taught Huitzilopochtli (alias Mexïtli),[1] Melantiuctli,[2] Tezcatzoacatl,[3] and the glories of Netzahual-coyotl[4] and Cuahtemoc.[5]

These be thy gods, O Israel!

There were old Spanish churches left, many of them not yet fallen to ruin, into which occasionally glided a few women muffled in black shawls, with their little children. Then a proscribed man might skulk in, perhaps, through a little door under the altar, and don for the mass priestly vestments which he was not allowed by law to wear outside the church. But the building you would find did not belong to him, but to the State. He could not, nor could any religious corporation, own property as religious societies do in the United States. If the Spanish bells in the tower were not melted down, he had no right to ring them; not to announce fair daylight to the sick-bed, not to bid an Angelus tell the laborer that it was

Gods—1. Of War. 2. Of Hell. 3. Pulque. 4. Tezcocan King, d. 1436. 5. Enemy of Cortez, d. 1525.

noon, not to sound a Vesper to "regret the dying day." But in the very midst of his murmured masses, in the crisis of the elevation of the Host itself, he might be interrupted by ruffians rushing in to ring a peal of their own, upon the receipt of news of some murderous victory, real or pretended.

In two skirmishes, so-called "battles," which I was regaled with, the church was the centre of the fight. In Monclova the women ran out of the church when the firing began, as they might with us after service, from a gathering thunderstorm. This was Sunday, November 12th ult., about noon. N. B.—Remington (American) bullets whistled about their ears.

Hoc ab initio persuasum civibus dominos esse omnium rerum ac moderatores DEOS; eaque quæ gerantur, eorum geri vi, ditione, ac numine. * * * * His enim rebus imbutæ mentes haud sane abhorrebunt ab utili et verâ sententiâ. It was an exotic—the Roman Religion—an imported article; but it was the last bond left to tie a good many unhappy souls together. It is nearly worn through. The last strands are parting. In short, the way things are going on, ten years ought to be a generous allowance for Mexico to rehabilitate the worship of her indigenous Gods of Hell, and Pulque, and War, and the sanction of public human sacrifice.

A continuation of Researches among the Batrachia of the Coal Measures of Ohio.

BY E. D. COPE.

(*Read before the American Philosophical Society, February* 3, 1877.)

The material described in the following pages was obtained from the coal strata at Linton, Ohio, during the Summer of 1876, by Prof. J. S. Newberry, Director of the Geological Survey of Ohio.

ICHTHYCANTHUS OHIENSIS. Cope. Gen. et sp. nov.

Char. Gen. These are derived from the posterior dorsal and caudal vertebræ, with adjacent parts. Posterior limbs well developed, with distinct tibia and fibula, osseous tarsus, and probably five digits. Ribs elongate, simple, curved. Abdominal armature consisting of bristle-like rods in anteriorly directed chevrons. Dorsal vertebræ not elongate, with simple neural spines. Tail large, its vertebræ ossified, and furnished with slender chevron bones which terminate in a hæmal spine. Neural spines slender and directed backwards; the caudal series somewhat resembling that of a fish. All the centra amphicœlian.

This genus differs from all those with enlarged and sculptured neural spines, and from those with abdominal scuta. It is equally distinct from those without ribs, abdominal rods, or limbs. It is possible that some of the species referred to *Tuditanus*, in which these parts are unknown, may belong to it, or that it may be established on a small species of *Leptophrac-*

tus, a genus only known as yet from cranial remains. With present knowledge the reference of the *I. ohiensis* to the latter genus is inadmissable. The cranium, thoracic region, and fore-limbs of *Ichthycanthus* are unknown.

Char. Specif. The centra of the dorsal vertebræ are about as long as deep, and their sides are deeply concave: there are four anterior to the pelvis which are without ribs. The caudal vertebræ are robust, and seven from the first, support a small tubercule-like diapophysis. The chevron bones are short and acuminate; the neural spines are a little shorter, narrow and truncate, and directed backwards at the same angle as the chevron bones. They are much reduced on the eighteenth caudal vertebra, where the chevron bones are considerably longer.

The abdominal rods are quite slender. The hind limb is quite stout for this order. The femur is regularly expanded at both extremities, but the distal is deeply and openly grooved, distinguishing the condyles, while the proximal end is plane. There is no trochanter visible. The ulna and radius are well separated, and are three-fifths the length of the femur. There is a large *fibulare* tarsal bone of a subquadrate outline. In immediate contact with it is the probably external digit with five phalanges or segments; the ungual is simply conic. The femur is as long as five dorsal vertebræ. The ribs have expanded, undivided heads, and extend to the abdominal armature.

Measurements.	M.
Length of last ten dorsal vertebræ	.047
" " first twenty-three caudal vertebræ	.117
" " a posterior rib	.029
" " " dorsal vertebra	.005
" " twenty-second caudal vertebra	.005
" " femur	.025
Proximal diameter of femur	.008
Width of lower leg	.009
Length of fibula	.015
" " tarsal bone	.006
" " digit	.027

This salamander is about the size of the *Menopoma allegheniense*.

Ichthycanthus platypus. Sp. nov.

This batrachian is represented by almost the same portions of the skeleton as the preceding species, furnishing a good basis of comparison. It is very well preserved, displaying the characters especially of the hind foot, which is almost entirely represented.

Several features distinguish it from the *I. ohiensis*, one of which is of more than usual value if correctly indicated by the fossil. There are ten vertebræ from anterior to the sacrum preserved in place, and none of them supports a rib, nor are there any ribs visible anywhere on the block of shale. I suspect that they exist on more anterior vertebræ, or may have been displaced to a more anterior position than they normally occupy.

The abdominal chevrons are more anterior in position than are those of the *I. ohiensis*. The hind legs are longer than in that species; in this one the femur equals seven and a-half vertebral centra in length. The external digit on the other hand, while bearing five phalanges, is distinctly shorter. The fibular tarsal is of a transverse oval, not quadrate, form.

The dorsal centra are short and deeper than long; the neural arches are elevated, with short but distinct zygapophyses, and a flat subquadrate, superiorly truncate neural spine. They bear short, vertically compressed diapophyses near the bases of the arches. The neural spines of the caudal vertebræ become rapidly more slender, and also diminish in length, while the zygapophyses are continued to the fifteenth vertebra, where the series is broken off. The chevron bones are slender, and enclose a moderate hæmal arch.

The femur is gradually expanded to the extremities Proximally there is a trochanteric ala besides the obtuse head. Distally the condyles are well distinguished, the external or fibular being truncate. The fibula is less than three-fifths the length of the femur, and is expanded at both extremities. Two proximal tarsals are distinct; the one next the fibula is larger than the other and transverse suboval in form. It has a median dividing ridge as though composed of the *fibulare* and *intermedium* coössified. The *tibiale* is subtriangular. There are five distinct phalangeal tarsals. The toes are in the order of their lengths beginning with the shortest, 1—2—5—3—4. Their phalanges (including metatarsals) are, in the proper order, commencing with the hallux, 3—3—4—?5—5; the distal end of the fourth finger being lost. These bones are rather stout, and the unguals are simply conic. The form of the foot is short and wide. The number of phalanges is nearly similar to that I have found in the *Amphibamus grandiceps*, excepting that in that species the fifth digit has but four. They are more numerous on most of the digits in *Sauropleura digitata*.

Measurements.	M.
Length of ten dorsal vertebræ	.045
" " fifteen caudal "	.055
" " the centrum of a dorsal	.0038
Total elevation of a posterior dorsal	.014
" of posterior of zygapophysis of dorsal	.010
Length of femur	.032
Diameter of femur medially	.0045
" " " distally	.0083
Length of fibula	.018
Diameter of fibula proximally	.007
Width of sole at second row of tarsal bones	.017
Length of foot to end of third digit	.031
" " first digit	.010
" " third "	.022
" " fifth "	.020

LEPTOPHRACTUS LINEOLATUS. Sp. nov.

This large batrachian is represented by the middle portion of a cranium, including parts of both jaws with numerous teeth. It is not easy to determine which of the tooth-bearing bones preserved is maxillary and which dentary, but the lighter and thinner of the two is presumably the latter, although it has the greatest vertical depth. The opposing bone supports two types of teeth, and as this is only the case in the maxillary of *Leptophractus obsoletus*, the present bone may be provisionally referred to that position.

There is a great difference in the sizes of the two types of maxillary teeth, the larger having nearly three times the linear dimensions of the latter. The small ones are rather distantly placed, being separated by interspaces nearly equal to their lengths. They are cylindric at the base, but become compressed, and have two opposite cutting edges on the apical third. They are of rather slender form, and are striate at the base. The longer teeth have a similar form, but are less strongly compressed distally, where there are two opposite cutting edges. The basal portion is quite closely striate. These teeth are on a different basal line from the small ones, since when their bases are removed the latter appear behind them. Three smaller teeth stand in the spaces between two large ones.

The mandibular teeth are intermediate in size between the large and small ones of the maxillary series, having a little more than half the linear dimensions of the former. Their terminal three-fifths are compressed, and furnished with fore and aft cutting edges.

The surface of the bone, where visible, does not display the punctate sculpture of that of the *L. obsoletus*, but is nearly smooth, displaying only fine parallel incised striæ.

Measurements.	M.
Depth of dentary bone at middle	.030
Length of mandibular tooth	.009
Antero-posterior diameter of mandibular tooth at base	.0035
Length of long maxillary tooth	.022
Antero-posterior diameter do. at base	.006
Length of small maxillary tooth	.007
Antero-posterior diameter do. at base	.002

The smaller size and slender form of the smaller maxillary teeth, as well as the peculiar sculpture distinguish this species from the *L. obsoletus*.

Another specimen of *Leptophractus* resembles the one above described in the form and disposition of the teeth, and has the osseous surface of both maxillary and dentary bones marked with shallow grooves and punctate impressions which do not inosculate. In this it resembles the maxillary bone of the large specimen figured on Plate XXXVII of the second volume of Paleontology of the Report of the Geological Survey of the State of Ohio.

Tuditanus tabulatus, Sp. nov.

This species is indicated by a specimen which includes a cranium, and the anterior part of the vertebral column. It is very well preserved on a block of shale, on both faces, and exhibits the constituent pieces of the cranium, the vertebræ, one of the thoracic shields with probable ribs. In all respects it conforms to the genus *Tuditanus* in characters; presenting a broad, flat head; osseous vertebræ and ribs; thoracic shields present, and abdominal chevrons probably absent. The last character is not absolutely assured, since the posterior two-thirds of the vertebral columns are wanting.

The cranium is wider than long, and the muzzle is broadly rounded. The orbits are wide ovals, and their posterior borders fall little behind the transverse line dividing the skull equally. The interorbital width equals the longitudinal diameter of the orbit. The posterior outline of the cranium is truncate in a straight, transverse line between the prominent epiotic angles. The distal extremities of the quadrates do not project so far backwards as the epiotic angles, and are still further removed from a transverse line marking the extremities of the occipital condyles. In this respect this species presents a strong contrast to the *Pelion lyellii*, where the ends of the quadrates extend posterior to the latter points. The composition of the superior cranial walls much resembles that of the *Tuditanus radiatus*. The epiotics are large bones, longer than wide, and present outwards strong angles, which correspond with the horns of *Ceraterpeton*. They enclose between them the posterior portion of the parietal, and the supra-occipital. The latter is a transverse bone, and not quite symmetrical in the specimen, one end having a greater antero-posterior extent than the other. The parietal is the largest cranial bone, is undivided, and is pierced by a median foramen behind the centre. Its general form is broadly wedge-shaped, the lateral borders expanding in front of the fontanelle, and contracting between the epiotics. The frontals are distinct and rather narrow. The post-frontals are rather large, are in close connection with the parietal on one side and the jugal on the other, and send a point backwards between the epiotic and supratemporal. The jugal widens fan-shaped backwards, joining two bones distally, a superior and an inferior. The former is the supra-temporal, but whether the inferior is quadratojugal or squamosal, I cannot determine. The boundaries of the bones of the extremity of the muzzle are not distinct.

The sculpture of the surface of the cranium consists of parallel ridges which are separated by grooves equal to them in width. The ridges radiate inwards on the epiotics and frontals, and outwards on the squamosal, and are transverse and interrupted on the supraoccipital. The lateral thoracic shield is covered with a similar sculpture of uninterrupted somewhat radiating ridges. The vertebræ are osseous, and rather small compared with the size of the skull. Opposite to the posterior extremity of the pectoral shields is a pair of slender bones, which are gently expanded and truncate at the extremities. It is not certain whether these belong to the

forearm, or are a pair of short ribs. Impressions only of the teeth remain; they indicate small pleurodont denticles like those of the *Anura*.

Measurements.	M.
Length of cranium above	.029
Width " "	.037
" between epiotic angles	.018
" of interorbital space	.007
" " orbit	.006
Length " "	.007
" " skull to fontanelle	.008
" " from orbit to nares	.005
" " " " " to end of snout	.003
" " lateral pectoral shield	.015
" " atlas	.004
Width " "	.004

This species of *Tuditanus* differs from the *T. radiatus* in the larger and less anteriorly placed orbits, and in the large truncate posterior table of the skull. The proportions of the latter are more those of *P. obtusus*, but the epiotic angles have not been observed in this species, the sculpture is punctate not linear, and the form of the supraoccipital is quite different. Comparison with the other species referred to that genus is unnecessary, excepting in the case of the *T. mordax*. Further examination of the specimen on which the latter was founded leads to the belief that it is an imperfect cranium of *Ceraterpeton punctolineatum* Cope. The latter name, as the preferable one, may be adopted, and the former becomes a synonym.

Colosteus scutellatus, Newberry; Cope, Rept. Geol. Surv. Ohio. Paleontology Vol. II, p. 407.

Another specimen of this species was obtained by Prof. Newberry during the past season, which includes some parts of the skeleton not previously observed.

The specimen presents a superior view of the ventral and thoracic protective armature, and of the posterior portion of the cranium. As heretofore, I find no indications of vertebræ, but along one side of the ventral scutellation, a series of slender ribs lies in the matrix. These I have not previously found in this genus. The cranial surface is only preserved on the lateral portions. Its sculpture consists of coarse grooves closely placed, directed outwards and forwards.

On a Dinosaurian from the Trias of Utah.

By E. D. Cope.

(*Read before the American Philosophical Society, February 16th,* 1877.)

Dystrophæus, Cope.

This genus reposes on scanty remains, but which are in good preservation, and which present marked characters. The bones consist of the humerus, three metatarsals, some ? tarsals, and the distal end of an ? ulna, with a probable sternum and an inferior element of either the scapular or pelvic arch, probably the latter. There is also a number of fragments, which are not easily identified. The specimens were discovered by Prof. J. S. Newberry in South-eastern Utah, while acting as Geologist to the Engineer Exploring Expedition under the command of Captain McComb, United States Army, He excavated them from the red and green rocks usually referred to the Trias, hence from the same formation which yielded the *Typothorax* already described. Professor Newberry made sketches of the bones as he exposed them. They were all, he states, found in close proximity, the bones of the limb in nearly normal relation. It is altogether probable, according to Professor Newberry, that they belong to a single animal. I find nothing to forbid this supposition and much to confirm it.

One of the most remarkable bones is a broad, flat element, one of whose borders is digitate, the processes being long, and separated by deeply entrant sinuses. Two sides of the bone are broken away, but the others give origin to five digitiform processes. Two of these are larger and longer than the others, and externally on the right side is a shorter one. Outside of this is a larger process whose extremity is recurved so as to be subparallel with the longer processes, and which was connected with another bone by an articular surface. This information is derived from Prof. Newberry's notes made in the field. It is probable that this bone is the sternum, and that the articulation mentioned is costal. It is not certain whether the longitudinal meridian line passes through a sinus or a digitation, but a projection of the surface of the plate, which is probably median, is opposite one of the latter. Supposing then that the sternum is produced into a median posterior process, we find a resemblance to the corresponding element in many birds not heretofore known among reptiles. There are in that case three postero-externally directed processes on each side, of which the two posterior are free. Another interpretation might be that it is a coracoid with anterior digitations. In this case the articulation above mentioned would be anomalous. The number of digitations is too great for this element, and the space remaining for contact with the sternum is too small.

Another large flat bone approximates a right-angled triangle in form, the length greatly exceeding the width. The right-angle is massive and

produced, and is evidently the point of connection with the other parts of the skeleton. The bone is flat on one side and convex on the other, and can only be identified with probability, with the scapula of a Dinosaurian reptile.

The large size of the anterior limb, which might be inferred from this scapula, is justified by the humerus, which is preserved in almost perfect condition. This humerus is one of the longest, and is distally the most contracted known in the *Dinosauria;* the proximal extremity is of the form usual in that order. A short distance below the head, the section is T-shaped, with one end of the transverse limb shorter than the other. The ridge of which this limb is a section, is almost wanting at the head, which is thus Γ-shaped. The limb representing the stem of the T is stouter than the others, and forms the summit of a massive column, which soon sinks into the shaft. Its free extremity is obtuse and rounded, and though representing the head, does not rise above the level of the other crests, or tuberosities. The distal extremity of the humerus looks much like that of a tibia. It is truncate, and its long axis is in the plane of the tuberosities of the head. Its outline is oval, one end narrowed to an angle, and the other broadly rounded. The surface is roughened with coarse pits.

The distal extremity of another long bone, most probably the ulna, is more robust than that of the humerus. The shaft is a flattened oval, and the articular extremity is a wide and somewhat irregular oval, the greatest transverse diameter being nearer one end. The articular surface is roughened with coarse pits.

Three metatarsals were found in immediate proximity to each other, two in nearly their normal relations, and one slipped forwards. They are neither remarkable for length nor abbreviation. The proximal ends are truncate, and the distal ones convex, but without distinct median grooves or lateral angles. Both extremities are moderately expanded, and the shafts are contracted at the middle. The external bone is a little shorter than the two others, and is more flattened. It has a slightly-defined convex head, with an adjacent prominent, but ill-defined, lateral crest. The larger of the longer bones has a crest at one angle, like that of an olecranon process. The proximal end of the same bone is massive, and is trapezoidal in outline; the outline of the corresponding head of the adjacent bone is triangular. A marked character of these bones is the rough or pitted surface of their articular extremities, except the distal end of the shorter bone. The shafts are solid, and filled with nearly equal, coarse cancelli.

The bones above described are evidently those of a Dinosaurian reptile, and they present characters which have not been previously observed in any other genus of the order. The form of the condyles of the humerus distinguishes it from the other known genera, especially from those of the European Trias, where the crest is weak or wanting.

The rugose articular surfaces are also peculiar, indicating less than the usual mutual movement of the bones upon each other. A cartilaginous cap is indicated, which was probably the element from which the mam-

malian epiphysis was derived. The sculpture of the surfaces is coarser than that to which epiphyses are attached in the *Mammalia*. The name of the genus expresses this character.

It is altogether probable that this genus embraced terrestrial animals, with powerful fore- and hind-limbs subequally developed. The typical species is of gigantic proportions.

Dystrophæus viæmalæ, Cope.

In the supposed sternum of this animal (which I have not seen, but which was sketched by Professor Newberry), a rather small, slender and compressed process projects from near the middle of one of the sides at right angles to it. Only two of the lateral processes are represented as complete. The longer is subspatulate; the shorter subacuminate. The scapula presents three complete borders,—the proximal and two lateral; but the distal is not known. Without it, the length is two and one-half times the breadth. The point of junction of the longer (and perfect) short border with one of the long borders, is much thickened, terminating in a mass of bone which is unfortunately broken, but whose section in the line of the end border is a wide oval. From this point, the plate thins away to the various borders. The greatest thickness is nearer the border which terminates in the enlargement described. This surface is then gently convex in transverse section, while the opposite one is concave to a less degree. It is thicker at the middle than at the anterior border in a longitudinal direction.

The proximal extremity of the humerus is much expanded. The greater tuberosity is a huge crest, as prominent as the head, and separated from it by a marked concavity which constricts the mass connecting it with the head, thus forming a neck. This concavity extends about one-third the length of the shaft. On the opposite side of the head a similar concavity excavates the shaft, separating the internal from the interior ridge. The latter is in its middle portion as prominent as the external ridge, and extends as far downwards. The extensive external face of this part of the bone is nearly flat.

The internal ridge descending from the head, continues into the posterior border of the interior face of the shaft. The great tuberosity continues into the single external ridge of the shaft, which is thus near the middle triangular in section, the base of the triangle internal. The external extremity of the distal end is therefore an angle, and the internal a convex side, shorter than the anterior and posterior sides. A ligamentous groove marks the posterior border of the extremity at a point measuring one-third of its length from the external angle. The expanse of the distal extremity is not more than three-fourths that of the proximal. The entire bone so resembles a tibia, as to have induced me to refer it at first to that element The characters of the proximal end are such as to render such identification highly improbable. Such reference would also require that the distal extremity should have a fore and aft direction, an arrangement incompatible with the tibia.

The displaced metacarpal is flattened, and expanded at the extremities. One side is nearly flat, but slightly concave in the longitudinal direction; the other side is convex and nearly level in the longitudinal direction. The lateral borders of the shaft are thus narrowed. The distal end displays a convex condyle, and a flat, prominent ala, which is in the general plane. The ala is separated from the condyle by a deep groove on the convex side. The condyle is a half-hemisphere only, presenting only with the convex side of the shaft, from which it is not separated by a constriction. It is bounded at its distal edge by an angle, which is a continuation of the proximal edge of the ala. The proximal extremity is injured at one angle, but, with this complete, would be nearly a regular rhomboid with parallel longer and shorter outlines; the acute angle of the latter being the continuation of the lateral border of the shaft. The extremity is subtruncate, and part of the surface is irregularly excavated by pits and grooves. The transverse extent of the proximal end, when perfect, was probably a little greater than that of the distal.

The two adjacent metacarpals are subequal in length, and longer than the displaced one by one-fourth the length of the latter. One of these bones is throughout rather thicker than the other, although the transverse diameter of the shafts is equal; but the stouter bone is considerably more dilated at the extremities. The distal end of the stouter bone is thickened in the direction at right angles to the plane of the limb; but the chief expansion is in that plane. The angle next to the other bone is protuberant, while the other angle is expanded into a sharp, convex crest, or ala. A section of this extremity is diamond-shaped, with one of the lateral planes produced into this crest, while the corresponding border of the opposite side drops down, being represented by a mere convexity of the surface which continues to the crest. The surface of the extremity is irregular. The section of the shaft is a broad oval, becoming subcircular near the proximal extremity. The latter is enlarged in both directions. It is a rectangle in outline, a little extended in the plane of the limb, with one of the angles cut off from the corresponding angle to the middle of one side. The long side thus left is slightly convex, and ends in an angle. The side subtended by this angle is slightly concave, and is approximated to the other bone. The opposite side is slightly emarginate near the middle. Its surface is very slightly convex, and is irregularly grooved and pitted.

The more slender of the two bones is but little and about equally expanded at the opposite extremities. The distal end would have an ovoid section, but for the fact that it is obliquely truncate at the extremity next to the other bone. It is convex in the antero-posterior direction and plane in the transverse; its surface is grooved and pitted. The side next to the other bone is flat or slightly concave at the distal end, and, though thicker than the external border, becomes rounded at the middle of the shaft, and is again flattened at the proximal extremity. The external border is distally produced into an obtuse angle; lower down, the shaft has a thin, angular border. The proximal end has less antero-posterior diameter than

the distal, and is subtriangular in outline; the apex being acute and external. The surface is flat, and is strongly marked with deep grooves. The other surfaces of the limb-bones are smooth, except a few weak ridges near the distal ends of the two distal bones.

Measurements.	M.
Length of part of scapula preserved	0.680
Width at middle	0.270
Thickness at middle	0.048
Thickness at proximal angle	0.117
Total length of humerus	0.765
Diameter of proximal end at head	0.080
Diameter of proximal end at tuberosities	0.225
Diameter of shaft antero-posterior	0.080
Diameter of shaft transverse	0.078
Diameter of distal end antero posterior	0.085
Diameter of distal end transverse	0.145
Transverse diameter of head of humerus	0.160
Diameter of extremity of ? ulna antero-posterior	0.110
Diameter of extremity of ? ulna transverse	0.150
Length of external metacarpal	0.210
Proximal diameter antero-posterior	0.045
Proximal diameter transverse	0.100
Diameter of shaft antero-posterior	0.033
Diameter of shaft transverse	0.067
Diameter distally antero-posterior	0.050
Diameter distally transverse	0.115
Length of median metacarpal (stouter)	0.245
Diameter proximally antero-posterior	0.057
Diameter proximally transverse	0.115
Diameter of shaft (transverse)	0.055
Diameter distally antero-posterior	0.074
Diameter distally transverse	0.088
Length of median metacarpal (slender)	0.240
Diameter of proximal end antero-posterior	0.057
Diameter of proximal end transverse	0.089
Diameter of shaft (transverse)	0.049
Diameter distally antero-posterior	0.041
Diameter distally transverse	0.083

More than usual interest attaches to this fossil. It is the first one found in the Triassic beds of the Rocky Mountain region, and was derived from an inhospitable region rarely traversed by white men. The locality is in the Painted Canyon not far from the Sierra Abajo in South-eastern Utah, near the Colorado boundary; lat. 38° 15′; lon. 110°. This canyon is one of those tributary to the Great Colorado River, and is without water. The rock is described by Prof. Newberry as the same as that which I

have identified in New Mexico as the Trias, and is of the usual red color. The occurrence of a terrestial Dinosaurian at that locality tends to confirm the conclusion to which I have already attained, that this immensely extended deposit is of lacustrine character.

On a New Proboscidian.

By E. D. Cope.

(*Read before the American Philosophical Society, March* 2, 1877.)

I recently received from a correspondent in one of the Southern States, a fossil of unusual interest. It is a molar tooth of a proboscidian, whose color and mineral character indicate that it was derived from beds of the Upper Miocene or Loup Fork epoch. Its roots are largely broken away, while the crown is nearly perfect.

The crown consists chiefly of two transverse crests, which are separated by a deep uninterrupted valley. There is no general cingulum. Each crest is divided into three lobes, which are not deeply separated, but cause the edge of the crest to be serrate with three conic eminences. Of these the median apex has a rounder section, while the lateral are more transverse, rising at the external borders like the extremities of the crests in *Mastodon ohioticus*. The appearance of the base of the crown at one extremity indicates that it was in contact with the preceding tooth. The opposite extremity of the base presents no such surface, and hence points to the conclusion that the tooth is the last one of the series. From the middle cone of the anterior crest a cingulum descends on each side, passing round the anterior base of the external cones. It is wanting at the extremity of the base of one of these, and little developed on the other, but they reappear on the side of the base bounding the valley. They are crenately tubercular, except at the base of the median anterior tubercle. There is no cingulum at the base of the posterior crest, except the ordinary filling between the bases of the lobes. One of the extremities of the crests is a little higher than the other, and the basis is a little wider than at the other end; it is therefore probably external in position. At the posterior base of this end is a fractured surface indicating a cingular tubercle of stout proportions, such as is more in place at the external posterior angle of the last superior molar than in any other tooth.

The external cone is defined from the median by a fissure, while a better defined depression separates the median from the internal. This depression is filled by a worn tubercle in the anterior crest. Ridges descend along the adjacent borders of the constituent cones nearly to the fundus of the valley, and the bases of the external ones are considerably wrinkled.

Measurements.	M.
Transverse diameter of crown	.130
Longitudinal " " internal	.070
" " " external	.090

Elevation of external cusp	.065
" internal "	.055
Length between apices of external cusps	.043

The molar tooth described exceeds in transverse dimensions that of the *Mastodon ohioticus*, and evidently belonged to one of the most colossal of land animals. Its generic position is near to *Mastodon* and *Dinotherium*, but if the tooth on which my observations are based be complete, it is distinct from either. The possession of only two transverse crests separates it from the former, and would, were the tooth an anterior molar, refer it to the latter. As it appears to be a posterior molar, this view of its affinity becomes untenable, and I therefore establish for it a new genus, under the name CÆNOBASILEUS. The tooth described resembles that of the genus *Tapirus*, but differs in the absence of the external trihedral enlargement of the cross crests seen in the superior molars of the former, and also in the tubercular and fissured character of the crests proper. The species may be called *C. tremontigerus*.

The typical specimen was probably obtained in Texas, but I am not yet informed as to the precise locality.

CONTRIBUTIONS FROM THE LABORATORY OF THE UNIVERSITY OF PENNSYLVANIA.

No. VIII.

On the Composition of the Natural Gas from certain Wells in Western Pennsylvania and New York.

BY SAMUEL P. SADTLER.

(*Read before the American Philosophical Society, March* 2, 1877.)

In February, 1876, I read before this Society a paper giving some results obtained in the analysis of the natural hydrocarbon gases of Western Pennsylvania. The material examined at that time consisted of the gases from the Burns Well and the Harvey Well in Butler Co., from the Rogers Well in Westmoreland Co., and the Cherry Tree Well in Indiana Co.

During the past summer I was again engaged in the service of the Second Geological Survey of the State, and spent a month in the Oil regions of Pennsylvania. While on this trip I collected six new lots of natural gases and have recently completed my examination of them.

These gases were the following :

1. A new sample from the Harvey Well in Butler County. This was taken as in the previous case from the delivery pipe in Spang, Chalfant & Co.'s Mills at Ætna, Alleghany County, Pa. An interval of nine months had elapsed and I wished to see if any differences in its chemical composition could be made out as having occurred in the meantime.

2. From a Well near Sheffield Station on the Philadelphia and Erie

R. R. in Warren County. This well had yielded only a trifling amount of oil but from it came a terrific outburst of gas. The geological horizon was totally different from that of the gas-wells in Butler County, being at least 600 feet lower. The gas had been used for some time to light the town of Sheffield and the tanneries there, being conveyed in pipes some two miles for that purpose.

3. From a Well some five miles from Wilcox Station on the Philadelphia and Erie R. R. in McKean County. Two wells had been sunk in this neighborhood for oil and both had yielded gas only. The geological horizon here is again different being some 400 or 500 feet lower than that of the Sheffield Well. The gas is not utilized at present.

4. From one of the gas wells at Erie, Pa. Quite a number of wells have been sunk at different times in the city of Erie, and the gas obtained has been utilized as fuel in the manufactories there. The specimen taken was from a well sunk by Oliver Bacon & Co., and the gas was used by them as fuel for their flour mills. This gas is again from a distinct geological horizon.

5. A specimen taken from the old well at Fredonia, N. Y., which has supplied the town of Fredonia for a number of years with a natural illuminating gas, was taken for analysis and comparison with those from the Pennsylvania localities. This gas is from a depth of 100 feet only.

6. A specimen was also taken from a new Well at Fredonia, which is now used for purposes of illumination. This gas comes from a depth of 1200 feet.

These gases were all collected, as in the previous cases, in glass tubes which were sealed before the mouth blow-pipe, while a current of the gas was still passing through them.

I will present with these new analyses those of the other gases published in my former paper. This is chiefly for the purpose of comparison. For this same reason I have classified the gases in several groups according to their geographical location.

I. *Gases from the Lower Oil Fields.*

1. Burns Well in Butler County. Collected in November, 1875.
2. Harvey Well in Butler County. Collected in November, 1875.
3. Gas from the same Well. Collected in August, 1876.
4. Rogers Well in Westmoreland County. Collected in November, 1875.

	1.	2.
Carbonic Acid (CO_2)	.34	.66
Carbonous Oxide (CO)	trace	trace
Ethylene series (C_2H_4)	——	——
Hydrogen (H)	6.10	13.50
Marsh-gas (CH_4)	75.44	80.11
Ethyl-hydride (C_2H_6)	18.12	5.72
Propyl-hydride (C_3H_8)	trace	trace
Oxygen (O)	——	——
Nitrogen (N)	——	——
	100.00	99.99

	3.	4.
Carbonic Acid	.71	.35
Carbonous Oxide	.24	.26
Ethylene series	.06	.56
Hydrogen	5.60	4.79
Marsh-gas	85.40	89.65
Ethyl-hydride	7.96	4.39
Propyl-hydride	trace	trace
Oxygen	.03	—
Nitrogen	—	—
	100.00	100.00

II. *Gases from Warren and McKean Counties.*

1. Sheffield Well in Warren County. Collected in August, 1876.
2. Wilcox Well in McKean County. Collected in August, 1876.

	1.	2.
Carbonic Acid	.09	.02
Carbonous Oxide	.24	.15
Ethylene series	—	.62
Hydrogen	3.12	7.55
Marsh-gas	78.42	62.37
Ethyl-hydride	18.00	29.29
Propyl-hydride	trace	trace
Oxygen	.13	—
Nitrogen	—	—
	100.00	100.00

III. *Gases from the Lake Erie border in Pennsylvania and New York.*

1. Erie gas from Erie, Pa. Collected in August, 1876.
2. Older Fredonia Well. Collected in August, 1876.
3. Newer Fredonia Well. Collected in August, 1876.

	1.		
Carbonic acid	.30		
Carbonous oxide	.61		
Ethylene series	—		
Hydrogen	.43		
Marsh-gas	40.33	98.59	69.44
Ethyl-hydride	58.26		trace
Propyl-hydride	trace		29.15
Oxygen	.07		
Nitrogen	—		
	100.00		

		2.			3.	
Carbonic acid		.44			.28	
Carbonous oxide		.84			.22	
Ethyline series		.42			.47	
Hydrogen		8.56			7.49	
Marsh-gas	40.83	89.73	65.28	26.99	91.55	59.27
Ethyl-hydride	48.90		trace	64.56		trace
Propyl-hydride	trace		24.45	trace		32.28
Oxygen		—			—	
Nitrogen		—			—	
		99.99			100.01	

The hydrocarbons of the Marsh-gas series in these three analyses can be counted together with perfect accuracy as 98.59 per cent., 89.73 per cent., or 91.55 per cent. respectively, or we have a choice of two methods of reckoning the individual amounts, with proximate accuracy however only. In these analyses the second method of estimation, viz: that dividing the amount between marsh-gas and propyl-hydride appears the more probable.

IV. *Gas from Indiana Co. Pa.*

1. Cherry Tree Well. This gas bubbles through a spring of fresh water and had to be collected over water. The totally different circumstances of its occurrence will explain in part the differences in composition. The geological horizon is much higher than that of any other gases analysed. It was collected in November, 1875.

	1.
Carbonic Acid	2.28
Carbonous oxide	—
Ethylene series	—
Hydrogen	22.50
Marsh-gas	60.27
Ethyl-hydride	6.80
Propyl-hydride	—
Oxygen	.83
Nitrogen	7.32
	100.00

A casual examination of these figures with a reference to the approximate geological horizon in each case will show several well-marked peculiarities. The Cherry Tree gas which comes from the highest geological horizon, is found to contain 22.50 per cent. of hydrogen and 60.27 per cent. of marsh-gas. This would make it the lightest of any of the gases analysed.

The four from the next lower geological horizon, *i. e.*, the Butler Co., oil-fields, show an advance upon this, and are quite similar, with two somewhat anomalous features showing, however—the 18.12 per cent. of

ethyl-hydride in the Burns Well gas and the 13.50 per cent. of hydrogen in the first sample of the Harvey Well gas. The gas from the Warren Co. geological horizon—obtained at the Sheffield Well—is very similar to the gas of the Burns Well in Butler Co.

The gas from the McKean Co. geological horizon—obtained at the Wilcox Well—is distinctly different from any of those preceding it. The 29.29 per cent. of ethyl-hydride makes it a heavier gas.

The three gases from the Lake Erie border however show the greatest differences. The per cent. of ethyl-hydride in these three analyses exceeds the per cent of marsh-gas, so that it becomes reasonable to estimate some of these heavy hydrocarbons as propyl-hydride. These three gases would be the heaviest of all those examined. An experimental determination of the specific gravity of the Erie gas made by the diffusion method gave .894. The specific gravity as calculated from the analysis was .845.

I will append several analyses of similar natural hydrocarbon gases that have come to my hand.

1. From a gas-well at West Bloomfield, N. Y. Analysed by Prof. Henry Wurtz. (Silliman's Journal (2) XLIX p. 336.)

2. From the Neff gas-well near Gambier, Knox Co. Ohio. Analysed by Prof. E. W. Morley, Hudson, Ohio. (Private communication.)

3. From a so-called "burning-spring" at St. Barthelemy, Isère, France. Analysed by F. M. Raoult. (Wagner's Jahresbericht 1870, p. 704.)

	1.	2.	3.
Carbonic acid	10.11	0.3	0.58
Carbonous oxide	——	0.5	——
Ethylene series	2.94	——	——
Hydrogen	——	——	——
Marsh-gas	82.41	81.4	98.81
Ethyl-hydride	——	12.2	——
Oxygen	0.23	0.8	0.10
Nitrogen	4.31	4.8	0.48
	100.00	100.00	99.97

In analyses No. 1 and No. 3, probably no attempt was made to distinguish between marsh-gas and Ethyl-hydride, and the figures given for marsh-gas probably express the sum of the marsh-gas hydrocarbons.

A description of the absorption tests by which I proved the presence of ethyl-hydride and propyl hydride and an explanation of the formulas by which the results of the gas-analyses were calculated appeared in my previous paper. (Vol. XVI, No. 97 of the Proceedings of the Am. Phil. Soc.; also reprinted in American Chemist for Sept. 1876).

On Eight Meteoric Fireballs seen in the United States from July, 1876, to February, 1877.

By Daniel Kirkwood, Professor of Mathematics in Indiana University, Bloomington, Indiana.

(*Read before the American Philosophical Society, March* 16, 1877.)

The number of meteoric fireballs observed in the United States during the latter part of 1876 and the beginning of 1877 has been quite remarkable. In several instances the meteors have exploded with tremendous detonations, and the disruption has been followed by the fall of aerolites. The description and analysis of the latter will doubtless be given to the scientific world by those who have devoted special attention to this department of research. In the meantime some account of the *meteoric* phenomena will not be without interest.

I.

The Great Meteor of July 8, 1876.

On the evening of July 8th, 1876, about fifteen minutes before nine o'clock, Chicago time, a very large meteor passed over Ohio and Michigan, and was visible in the adjacent States of Iowa, Illinois and Indiana. At Wolcottville, La Grange County, Indiana, it was well observed by Mr. William L. Taylor, a member of the senior class in Indiana University, who states that the point of first appearance was almost exactly East of Wolcottville, and at an elevation of nearly 60°. At Valparaiso, Porter County, Indiana, according to Rev. Robert Beer, it appeared a little North of East; while at Chicago it seemed to start from a point somewhat South of East and about 25° above the horizon. Mr. Benjamin Vail, of Henryville, Clarke County, Indiana, and Mr. J. W. Hollingsworth, of Paoli, Orange County, each saw the meteor under favorable circumstances. According to the former, its direction from Henryville, when first visible, was about North North-east. The observations of Messrs. Taylor and Vail thus determine the point of first visibility, while the notes of Mr. Hollingsworth, in connection with observations at Bloomington, Indiana, indicate almost precisely the same position. The body was first seen over Fulton County, Ohio, not far from latitude 41° 40′ North, longitude 84° West.

Altitude when First Visible.

Mr. Vail, who is known by the writer to be generally accurate, says the apparent altitude of the meteor when first seen at Henryville, was about 20°. The distance from that place to Ottokee, Fulton County, Ohio, is 226 miles. Mr. Vail's observation gives, therefore, about 88 miles as the vertical height of the meteor when first observed. The Paoli, Wolcottville, and Chicago observations indicate very nearly the same result.

The Point of Disappearance—Course and Length of the Visible Track.

The meteor crossed the meridian of Paoli at Berrien, Michigan; the difference of latitude of the two positions being 235 miles. Mr. Hollingsworth says: "My observer, Mr. J. M. Andrew, describes the meteor as 'grazing' a chimney-top which was *on* his meridian 400 feet distant, and 51 feet more elevated than the observer's eye." The angle of elevation when on the meridian of Paoli was, therefore, 7° 16′. Taking into account the curvature of the earth's surface, these data give 37 miles as the altitude of the body when passing Berrien, Michigan. At Wolcottville, La Grange County, Indiana, the bearing of the point of disappearance was North 70° West, and its apparent elevation about 25°. At Chicago it was stated to be at an elevation of 50°, and somewhat North of East. These observations indicate a point over Lake Michigan, in latitude 42° North, longitude 86° 55′ West. This point is 40 miles from Chicago, 78 from Wolcottville, and 135 from Ottokee, Ohio. The altitude of the meteor at the time of its disappearance, according to the observations at Chicago and Wolcottville, was about 34 miles; the bearing of the track, or of its projection on the earth's surface, was North 78° West; and it was inclined to the horizon at an angle of 21°. The meteor passed vertically over the counties of Fulton and Williams, Ohio; the North-east angle of Steuben County, Indiana; and Branch, St. Joseph, Cass and Berrien, Michigan.

"The meteor was a very brilliant one. It lighted up the sky like the glare of a calcium light; the intensity being several times greater than the light of the full moon."* Its mass was apparently dissolved or dissipated in the latter part of its track, leaving a luminous train which continued visible at least 40 minutes. The disappearance of the body was followed by no detonation, and if any meteoric fragments fell from the terminus of the track they must have been lost in the lake. No part of the mass, it is sufficiently obvious, could have passed out of the atmosphere.

The rare occurrence of meteors whose trains remain visible from fifteen minutes to an hour or more, seems to indicate a remarkable peculiarity in their structure and composition. Professor Ennis has suggested that they probably consist of elements easily combustible, such as potassium, sodium, calcium and magnesium.†

This meteor's motion about the sun was retrograde. The observations, however, furnished no data—or none sufficiently trustworthy—for determining either its orbital velocity or the nature of the orbit in which it moved.

II.

The Second Meteor of July 8, 1876.

Soon after the appearance of the meteor above described, the writer in a published note expressed his regret that the observations furnished by

*Chicago *Tribune*.

† Proc. of the A. A. A. S., Indianapolis Meeting.

correspondents were insufficient to determine, even approximately, the orbit of the meteor. In response to this note a communication was received from E. Lyon Linsley, of Stratford, Connecticut, who, on the same evening and nearly at the same hour, had observed a large fireball, and who supposed it to be identical with that seen in Michigan. The following is an extract from the Stratford letter:

"I saw this brilliant meteor here, on the evening of July 8th, at about nine o'clock. It was then about eight degrees from the polar star, and close to the faint northernmost visible star in the constellation *Camelopardalis*. Whether it expired then and there or disappeared behind an angle of the roof, I am unable to say; viewing it as I did from an Eastern portico, which was suddenly all aglow with its celestial light, and seeing meteor and illumination each but for a moment."

The slightest examination shows that the bolide here described was different from that seen in Michigan and the adjoining States on the same evening. We conclude accordingly that two fireballs of great brilliancy were simultaneously observed. Were they cometary fragments whose orbit intersects that of the earth near the 288th degree of longitude? It is a remarkable coincidence that on the 8th of July, 1856, somewhat earlier in the evening, a large fireball was seen in Alabama and Mississippi, which, like the meteor first described, left a luminous train that remained visible a considerable time near the terminus of its track.* It may also be mentioned as an additional coincidence that a meteoric stone-fall occurred in Spain on the 8th of July, 1811.

III.

The Fireball of December 16, 1876.

A large majority of the meteorites which reach the earth's surface must doubtless fall into the ocean, though the phenomena of their descent are very rarely witnessed. An occurrence of this kind was observed, however, according to the San Francisco daily papers, on Saturday morning, December 16, 1876, about fifteen minutes before one o'clock, when a large meteoric fireball appeared over the Pacific Ocean westward from San Francisco. When first seen it was rapidly descending towards the surface of the ocean, its apparent path making a large angle with the horizontal plane. It had been visible but a few seconds when it plunged into the Pacific at apparently no great distance from the shore. The fall was followed by a loud detonation.

IV.

The Meteor of December 21, 1876.

On Thursday evening, December 21, 1876, about seventeen minutes before nine o'clock, Bloomington time, a meteor of extraordinary magnitude passed over the States of Kansas, Missouri, Illinois, Indiana, Ohio,

* See Am. Journ. Sci. for November, 1856, and January and May, 1857.

Pennsylvania and New York. I have received communications descriptive of the phenomena from Prof. F. W. Bardwell, of Lawrence, and Rev. J. L. Gay, of Parsons, Kansas; Prof. Joseph Ficklin, Columbia, Mo.; Prof. S. W. Burnham, Chicago, Ill.; Profs. D. E. Hunter, Brookston, and J. B. Roberts, Indianapolis, Ind.; Prof. Samuel J. Kirkwood, Wooster, O.; and others in the different States over which the meteor passed. At Bloomington, Ind., it was observed by Profs. T. A. Wylie, D.D., H. B. Boisen, and C. F. McNutt; also by Rev. James Garrison, Messrs. D. O. Spencer, J. Graham, and many others. A discussion of the observations furnished by the correspondents named gives the following as

The Meteor's Track through the Atmosphere.

The body when first visible was about 70 or 75 miles above the earth's surface, at a point South-west from Emporia, Kansas, and not far from the Southern border of the State. It passed Emporia a few degrees South-east of the zenith; entered Missouri near the South-west corner of Jackson county; passed very nearly over the towns of Lexington, Keytesville, and Oakdale, Missouri; Quincy, Lewiston, Peoria, and Lorain, Illinois; Winamac, Rochester, and Auburn, Indiana; Bryan and Toledo, Ohio; crossed Lake Erie to a point a few miles South of Erie, Pennsylvania, and disappeared over South-western New York. This track is not represented by a straight line drawn on the map, but by one somewhat curved towards the North or North-west. Its length is between 1000 and 1100 miles—one of the longest meteoric tracks on record. The body passed the meridian of Bloomington, Indiana, 131 miles North of the city, and its apparent elevation as determined by Prof. T. A. Wylie, D.D., was 15°. This, taking into account the curvature of the meridian, gives about 38 miles as the altitude of the meteor when over the Western part of Fulton county, Indiana. Data furnished by Prof. Samuel J. Kirkwood, of Wooster, Ohio, show the height when over Lake Erie, directly North of that city, to have been 29 miles. The estimated altitudes at other points of the track are less satisfactory.

Explosions.

Some observers in Missouri report an explosion of the meteor when passing over the central part of the State. At Bloomington, Indiana, Prof. H. B. Boisen, who saw the meteor when due West and watched it till it disappeared near the Eastern horizon, observed it separate into several parts when nearly North-west, or in the direction of Peoria, Illinois. Rev. James Garrison, who resides one mile South of Bloomington, noticed by his clock the time of the meteor's disappearance and also that of the subsequent rumbling sound together with the violent jarring of his house. The interval was 15 minutes, indicating a distance of 185 miles. The sound and jar of the explosion were heard and felt by hundreds throughout Monroe county, and by many ascribed to an earthquake. In regard to the sounds following the meteor's passage through the atmosphere, the

Monthly Weather Review for December, 1876, says: "No reliable accounts speak of any noise heard during the visibility of the meteor, but in from two to five minutes after its passage a shock resembling thunder was heard, which in the majority of cases was described as tremendous, shaking the ground and the houses, and was especially alarming to those who, on account of the prevailing cloudiness, were unable to see the preceding meteor. The uniform character of the sound heard at all the stations shows that it was not due to any violent explosion (properly so-called), but was a peculiar acoustic phenomenon, depending on the fact that that portion of the line described by the meteor when nearest to any observer, became, as it were instantaneously along a length of several miles, the origin of a series of simultaneous sounds which, although in themselves comparatively feeble, were concentrated into a violent sound when they reached the observer's ear." The view here expressed is not sustained by the observations in Monroe and the adjacent counties, as a sound from the nearest point of the meteor's track would have reached Bloomington, if at all, in 10 or 11 minutes.

When crossing Indiana the principal fireball was followed by a train or group of smaller meteors, many of which were superior in apparent magnitude to Venus or Jupiter. The breadth or apparent diameter of this cluster, as seen from Bloomington, was three degrees, and its length at least twenty degrees. Its true diameter was therefore five miles, and its length about forty miles. These smaller meteors were chiefly the results of the explosions over Central Illinois. A final disruption occurred over Erie county, Pennsylvania; several minor explosions having taken place during the passage over Indiana and Ohio.

The Fulton County Fragment.

A fragment of the meteorite fell on the farm of Mr. Andrew J. Morris, three miles North-west of Rochester, Fulton county, Indiana. Mr. M., on hearing the meteoric explosion, had left his house, when he noticed a heavy body strike the earth at no great distance. Designating the spot as nearly as he could by a mark in the snow (which was six inches deep), he returned in the morning, and soon found where the meteorite had struck in the snow, rebounded and again fallen close by. The whole fragment weighed about 12 ounces. A part of it was secured by the writer and forwarded to Prof. Chas. Upham Shepard, of Amherst College, Mass. A fragment was also obtained by Mr. W. A. Roebling, of New York, and a third was sent by Prof. E. T. Cox to Dr. J. Lawrence Smith, of Louisville. No analysis, however, has yet been published. The body is peculiar in its structure; being pisolitic and remarkably friable. The fact that other portions of the mass have not been discovered may perhaps be owing to its complete disintegration.

Did the Meteor Pass Out of the Atmosphere?

The observations at Bloomington, Indiana, and Wooster, Ohio, indicate that in a flight of 200 miles eastward from Rochester the altitude dimin-

ished from 38 to 29 miles. The elevation, when over Erie County, Pennsylvania, was almost certainly less than 30 miles—probably not more than 25. After the explosion, near the South-western border of New York, the meteor became almost immediately extinct. In view of these facts it seems extremely improbable that any part of the mass could have escaped out of the atmosphere. What became of the dissevered fragments, or why none have been hitherto found near the terminus of the track, may be difficult of explanation.

Velocity.

I have not learned that the time of the meteor's visibility was by any one accurately measured. The slowness of the apparent motion was, however, very remarkable; being compared by many to that of a flock of wild geese. Several observers estimated the duration of flight at nearly two minutes. The velocity with reference to the earth's surface was probably between 8 and 12 miles per second, and with reference to the sun, between 25 and 30.

V. and VI.

The Meteors of January 3 and January 20, 1877.

The fall of ærolites, attended with the usual meteoric phenomena, occurred in Warren County, Missouri, on the 3d of January, 1877, and in Georgia, January 20th. Fragments of these bodies have been secured by Professor J. Lawrence Smith, of Louisville, Kentucky, from whom full descriptions and analyses may soon be expected.

VII.

The Meteor of January 23, 1877.

About 4 o'clock on Tuesday afternoon, January 23, 1877, a splendid meteor was seen at Gray's Mills, five miles North of Bloomington, Monroe County, Indiana, by Mr. Daniel J. Stout and several other gentlemen in company with him. Its position when first seen was nearly South-east from the place of observation, and about 35° above the horizon. Its visible track was very nearly perpendicular to the earth's surface. When near the horizon the meteor disappeared behind a hill South-east of the observers, but the disappearance was followed by no detonation. The same meteor was observed by a number of persons in Decatur County, five miles East of Greensburgh, latitude 39° 27′ North, longitude 85° 28′ West. According to the Indianapolis *Daily Journal*, of January 25th, the meteor "disappeared just as it seemed to touch the earth, apparently not more than one-fourth of a mile distant. It presented the appearance of a flexible band of beautifully polished silver, and as it pursued its downward course waved like a ribbon in the breeze. Exclamations of astonishment and admiration burst simultaneously from the lips of all who saw it." A letter in the Cincinnati *Weekly Gazette*, dated at Scott's Post Office, Kenton County,

Kentucky, January 25, states that "about 4 o'clock on the evening of the 23d, a heavy rumbling sound was heard, as if coming from a South-easterly direction, and from a point high in the heavens. The report was likened by some to the discharging of numbers of heavy ordnance, the different discharges barely distinguishable. The concussion was sufficient to rattle the glass in the windows, and also to jar the earth quite perceptibly. The course of the sound appeared to be from a point South South-east" of the writer's place of observation. The final explosion took place over Harrison County, Kentucky, and the ærolite reached the earth nine miles North of Cynthiana. It is now in the collection of Dr. J. Lawrence Smith, of Louisville.

The points from which this meteor was observed in Decatur and Monroe Counties are nearly on the same parallel; the latitude of the former being about 39° 27′, that of the latter 39° 21′. The distance between the stations is 56 miles, and the entire track, as seen from Decatur County, was East of the meridian. The observations in Monroe County indicate that the height of the meteor when first seen was at least 70 miles.

VIII.

The Meteor of February 8, 1877.

About half past 2 o'clock on Thursday morning, February 8th, 1877, a large meteor was seen by J. S. Hunter, Esq., near Ellettsville, Monroe County, Indiana. The apparent magnitude of the body seemed equal to half that of the full moon, and the sudden light was so intense as to frighten the horse of the observer. The meteor was first seen in the South-east, crossed the meridian South of the zenith, and disappeared at a point about 30° or 35° South of West, and 10° above the horizon. Numerous sparks were emitted by the body in the latter part of its track, and a luminous train remained visible several seconds. No explosion was heard.

Bloomington, Ind., *March* 7, 1877.

On the Asserted Antagonism between Nicotin and Strychnia.

By Francis L. Haynes, M. D., Assistant Surgeon to the Episcopal Hospital.

(*Read before the American Philosophical Society, March* 16, 1877.)

History.

Haughton's Experiments. The Rev. Prof. Haughton, in a communication read before the Royal Irish Academy, in Nov. 1856, was the first to call attention to the subject under consideration. He related the details of the following experiments on frogs: 1. A frog was placed in a bath composed of five ounces of water and five grains of nicotin. It died in twenty-three minutes. 2. A frog was placed in a bath of twenty ounces of water

and five grains of nicotin. It died in forty-three minutes, with peculiar convulsions. 3. A frog, placed in a solution of strychnia (five grains to five ounces of water), was immediately seized with tetanic convulsions, and died in four minutes. 4. A frog, placed in a solution of strychnia (five grains to twenty ounces of water), became speedily convulsed, and died in fifty-five minutes. 5. A frog, placed in a bath containing nicotin and strychnia (of each five grains to ten ounces of water), remained there nineteen minutes without any inconvenience, when it was seized with tetanic convulsions, which continued, but with less violence than in the previous experiments. After forty-seven minutes, the animal was removed, and washed in cold water. It lived afterwards more than twenty-four hours, exhibiting at intervals tetanic convulsions. 6. A frog was placed in a bath of nicotin and strychnia, as in the last experiment, and removed after ten minutes. In forty-two minutes, tetanic convulsions appeared, and continued for many hours, but they were succeeded by perfect recovery.

Wormley's Experiments. To each of thirteen cats, one-half grain of strychnia was given. "The poison was passed in solution into the stomach, by means of the stomach-tube. In some instances, as soon as symptoms of poisoning appeared, an infusion of twenty grains of tobacco leaves was administered, in the same manner as the poison; while, in others, the tobacco infusion was given along with the strychnia, the two infusions being thoroughly mixed. In some few cases, the dose of tobacco was repeated. As the result of these experiments, one of the animals, which had taken the mixed solutions, immediately fell prostrate, breathed with difficulty, in three minutes voided urine, in eight minutes vomited a frothy mucus, and in ten minutes was able to run, with, however, a stiff gait. After an hour, the animal appeared perfectly well, with the exception of a slight stiffness in walking. With this single exception, all the animals died, and, in most instances, within the usual period. One of them, however, that had taken the mixed solutions, manifested no symptom whatever, for thirty-five minutes. In some instances, the strychnine symptoms appeared to be not in the least affected by the tobacco. But, in others, they were of a compound nature. Several of the animals vomited. Before performing these experiments, it was ascertained that an infusion of twenty grains of tobacco, given alone, would produce serious symptoms; but, in no instance, in six experiments, did it cause death."—(*Micro-Chemistry of Poisons*, New York, 1865, p. 545.)

Reese's Experiments were made on dogs. The drugs were, as a rule, given by the mouth. 1. Three-fourths of a grain of strychnia, hypodermically, killed a moderate sized dog, in nine and one-half minutes. 2. Three-fourths of a grain of strychnia, and two drachms of a concentrated infusion of tobacco, were given by the mouth. Twenty-six minutes, tetanic spasms; thirty-one minutes, non-tetanic spasm; thirty-three minutes, somewhat tetanic spasm; thirty-nine minutes, one-half drachm of infusion of tobacco was given hypodermically, and was immediately followed by a tetanic spasm, and death. 3. Two drachms of tobacco infusion. Five minutes, free

vomiting; twenty minutes, quite well. Thirty minutes, three-fourths grain strychnia and two drachms tobacco infusion given; trembling, panting respiration. Forty three minutes, tetanic spasm; forty five minutes, death. 4. Two drachms tobacco infusion; uneasiness, panting, vomiting, recovery. Twenty-five minutes, the dose was repeated; vomiting, trembling, panting. Fifty-one minutes, two drachms tobacco infusion with one-half grain strychnia; weakness, panting and trembling. Eighty-nine minutes, the combined dose of tobacco and strychnia repeated; noisy and panting respiration, increased reflex excitability, spasms sometimes tetanic and sometimes not. One hundred and nine minutes, died, without convulsion. 5. Half a drachm of tobacco infusion, hypodermically, repeated in five minutes; six minutes, retching and vomiting; fourteen minutes, strychnia, one third grain hypodermically; seventeen minutes, tetanic spasm; nineteen minutes, death.—(*Am. Jour. Med. Sci.*, April, 1871, p. 382.)

Cases of Strychnia Poisoning Treated by Tobacco.

O'Reilly's Case. A sailor took six grains of strychnia in beer. Soon after, he took an emetic, and vomited freely, but, notwithstanding, violent symptoms set in. One and a quarter hour after he had taken the strychnia, he was given an infusion of tobacco, and this was continued at intervals. After about twelve hours, all the symptoms had disappeared. It is not stated how the tobacco acted, but, merely, that in two hours after he had commenced taking tobacco, "favorable symptoms set in." In all, an infusion of one and a quarter ounce of tobacco was used. (*British and Foreign Medico-Chirurg. Rev.* Oct., 1859, p. 532.)

Smyly's Case. A boy, aged 15, swallowed as much strychnia as would cover a shilling, and ate a quantity of raisins to take away the taste. In forty minutes, he fell into his master's arms, tetanic. Tartar emetic was given, but it did not act. He was put under chloroform, and removed to a hospital. Emetics were given, but did not act. Next an infusion of three ounces of tobacco, in three pints of tepid water, was given, in three doses. Each dose was followed by furious vomiting. Profuse sweating occurred; the patient slept, and had no further trouble. (*Dublin Quart. Jour.* 1862, p. 183.)

Chever's Case. A Mohammedan girl, aged 11, took about three grains of strychnia, chewed it, spat out, as she thought, the whole of it, and then swallowed some water to remove the taste. In about forty minutes, a convulsion occurred. An emetic was given by the husband. She was taken to a hospital, three hours after taking the strychnia, and, up to that time, had had five convulsions. An emetic was given, and followed by large quantities of animal charcoal and lard, and small doses of infusion of tobacco. Two hours after admission, a severe convulsion occurred, lasting six minutes. Three hours after admission, there was free vomiting. Recovery ensued. She received in all, *two and one third grains* of tobacco in infusion. It is stated that none of the emetics given acted satisfactorily, until the tobacco was given. (*British and Foreign Medico-Chirurg. Rev.* 1876, p. 242.)

Writer's Experiments.

The following experiments were made on rats, cats, rabbits, and dogs. The poisons were invariably injected under the skin.

The time given refers to the period of the injection of the poison ; or, if more injections than one were made, the time is dated from the first injection.

In all cases in which an animal was killed by strychnia, or nicotin, or by both combined, the heart continued to beat for a variable time after respiration had ceased.

A. *On Rats.*

The ordinary stable rats were used. First, the minimum fatal dose and the physiological action of nicotin were determined, and, next, the action of nicotin and strychnia combined.

I. *Minimum Fatal Dose of Strychnia Sulphate on Rats.*

This was found by J. Hughes Bennett (*Antagonism of Medicines*, London, 1875, p. 14) to be about 1-60 of a grain of the pure alkaloid. The rats used by Bennett averaged about one ounce more in weight than those employed by the present writer. Of course the dose of the sulphate is proportionally larger.

II. *Minimum Fatal Dose and Physiological Action of Nicotin on Rats.*

When a small dose of nicotin (♏1-1000 to ♏1-600) is injected into a rat, its respiration becomes labored, and, sometimes, noisy ; and the animal shows signs of prostration, but is able to make voluntary motions. After larger doses (♏1-600 to ♏1-140), convulsions occur, which may be either clonic or tetanic. The convulsions may be preceded, and are always succeeded, by more or less complete paralysis of motion. One convulsion may terminate life, but, generally, the animal survives through several convulsions. The respiration, after each convulsion, ceases for several seconds, and, sometimes, for more than a minute. When death occurs, it is through failure of the respiration. The heart invariably continues to beat for a time after respiration has ceased. Purging and urination are frequent symptoms.

From the following experiments, the minimum fatal dose of nicotin, for rats, was found to be about 1-150 of a minim (taking the average weight to be about $10\frac{1}{4}$ ounces).

Table I.

Showing the Effects of Nicotin on Rats, and indicating the Minimum Lethal Dose.

No.	Weight of Rat.	Dose of Nicotin in parts of a Minim.	Result.	Symptoms.
1	10¼ oz.	1-1000	Recovery.	Ran around the room actively for 5 minutes, then less actively till 10th *min.*; after which lay quiet unless disturbed, when it ran, but with difficulty. Respiration, after 5th *min.*, difficult—the walls of the chest exhibited a greater extent of motion than usual. Could be handled, without biting. 37 *min.*, recovering.
2	10¼ oz.	1-800	Recovery.	Immediately lay quiet and breathed laboriously, and after the 6th *min.* noisily. At intervals, slight convulsive movements. At no time was there inability to move when disturbed. 13 *min.*, recovering.
3	6¼ oz.	1-700	Recovery.	After ½ *min.*, lay quietly, breathing laboriously. 4 *min.*, can barely move when disturbed. Respiration noisy, and slower than normal. 8½ *min.*, respiration gasping, 58 a minute. 22 *min.*, respiration still labored, 80; moves more readily.
4	10¼ oz.	1-666	Recovery.	Panting respiration, and semi-paralysis. Recovery after 30 *min.*
5	10¼ oz.	1-600	Recovery.	Same as in last experiment.
6	8 oz.	1-600	Death.	After 15 *sec.*, hissing and laborious respiration; moved rapidly around the cage till 40 *sec.*; then lay, gasping for breath, till 60 *sec.*, when tetanoid convulsions occurred, which caused respiration to cease at the end of the 2d *min.*
7	11 oz.	1-550	Recovery.	½ *min.*, difficult respiration. 1 *min.*, paralysis. 2½ *min.*, clonic convulsions with opisthotonos, which continued at intervals till 8*th min.*, when they ceased, and the respiration became gasping and infrequent, 10 per minute; and there was complete motor paralysis. 12 *min.*, respiration re-established, hissing. 35 *min.*, slight voluntary movements. 60 *min.*, almost constant convulsive trembling, with laborious and occasionally noisy respiration. 2 *hrs.* condition the same. Very slight movements occasionally.
8	6½ oz.	1-500	Recovery.	Same as in last experiment.
9	8¼ oz.	1-440	Recovery.	Immediately difficult respiration. ½ *min.*, violent tetanic convulsions, succeeded by panting noisy respiration, and complete motor paralysis. Very rapid muscular quiverings, causing such rapid movements of one foreleg that they could scarcely be seen. 19 *min.*, recovering voluntary power.
10	10¼ oz.	1-400	Recovery.	Usual symptoms. Convulsions clonic and tonic.
11	10 oz.	1-300	Recovery.	Usual symptoms. Convulsions clonic.
12	10 oz.	1-230	Recovery.	Difficult respiration, slight clonic convulsions, and semi-paralysis.
13	11¼ oz.	1-230	Recovery.	Difficult respiration, no convulsions, semi-paralysis.
14	10¼ oz.	1-230	Recovery.	Same as in last experiment.
15	8 oz.	1-230	Recovery.	Difficult respiration. 3½ *min.*, violent tetanic convulsions, after which respiration ceased for 15 sec., then recommenced with a gasp. There was semi-paralysis for a few minutes, but by 18 *min.* the animal had almost recovered.
16	4½ oz.	1-200	Death.	Immediately clonic convulsions, which ended fatally in ½ *min.*
17	10¼ oz.	1-194	Death.	Ran around the room for ½ *min.*, when he stopped, and the respiration was noted noisy and laborious. 2 *min.*, complete motor paralysis. 3½ *min.*, violent clonic convulsions lasting till 4½ *min.* Respiration now ceased till 5½ *min.*, recommenced with a gasp, and ceased finally at 6 *min.*

TABLE I.—CONTINUED.

No.	Weight of Rat.	Dose of Nicotin in parts of a Minim.	Result.	SYMPTOMS.
18	7¾ oz.	1-176	Death.	1½ *min.*, convulsions, succeeded by difficult respiration and semi-paralysis. 25 *min.*, complete paralysis. 2¼ *hrs.*, moves limbs slightly when disturbed. Death at 3 *hrs.*, the respiration falling gradually down to 6, then to 1, per minute.
19	10⅛ oz.	1-176	Recovery.	1 *min.*, labored respiration. 4 *min.*, prolonged tetanic convulsion, followed by the usual respiratory difficulty and semi-paralysis. 60 *min.* recovery.
20	9¼ oz.	1-143	Death.	½ *min.*, noisy, labored respiration; convulsions, lasting 3 min., then almost complete paralysis. 53 *min.*, convulsions excited by slight irritation, semi-paralysis till 144 min., when slight voluntary motions were noted. 20 *hrs.*, respiration feeble, 30; lay powerless on the side, and had tetanic and clonic convulsions when disturbed. 20½ *hrs.*, heart beats, 93; respiration, 15. Entire paralysis. 23 *hrs.*, death from failure of respiration, which had occurred once a minute for some time previously.
21	7¾ oz.	1-143	Death.	Same as in last experiment. Death after 5 *hrs.*

III. *Effects of Nicotin and Strychnia Sulphate, when Injected Simultaneously.*

First, the drugs were injected in less than fatal doses; next, fatal doses were employed.

TABLE II.

Strychnia Sulphate and Nicotin, injected simultaneously, in Non-fatal Doses.

No.	Weight of Rat.	Dose of Strychn. Sulph. in parts of a grain.	Dose of Nicotin in parts of a Minim.	RESULTS.	Result of Crucial Experiment performed Nine Days afterwards.
22	9¾ oz.	1-96	1-1000	Ran around the room actively for 4 *min.*, then kept quiet, unless disturbed, for ½ *hr.* During this time, the respiration was panting.	Strychnia Sulphate gr. 1-96, alone, produced no effect. For the effect of ♏ 1-1000 Nicotin see Experiment 1.
23	8⅛ oz.	1-96	1-800	After 1 *min.*, difficult respiration and prostration. 8 *min.*, almost complete paralysis, convulsive motions occasionally. Increased reflex excitability. 27 *min.*, recovering.	Strychnia Sulphate, gr. 1-96, alone, produced a slight increase of reflex excitability. For effects of Nicotin, ♏ 1-800, see Experiments 1, 2, and 3.
24	10¼ oz.	1-64	1-800	Difficult respiration, increased reflex excitability, and indisposition to move.	Strychnia Sulphate, gr. 1-64, produced slight increase of reflex excitability.
25	10¼ oz.	1-96	1-666	Very difficult respiration, and semi-paralysis. The animal had scarcely begun to recover at the end of 45 *min.*	Nicotin, ♏ 1-666, produced difficulty of respiration and semi-paralysis lasting 30 *min.*

TABLE II.—CONTINUED.

No.	Weight of Rat.	Dose of Strychn. Sulph. in parts of a grain.	Dose of Nicotin in parts of a Minim.	RESULTS.	*Result of Crucial Experiment performed Nine Days afterwards.*
26	11 oz.	1-96	1-400	Immediately, difficult respiration and almost complete paralysis; then convulsive trembling. At 11 *min.*, violent convulsions, after which there was semi-paralysis, with very difficult respiration.	Nicotin, ♏ 1-400, produced difficult respiration, semi-paralysis, and convulsions.
27	8 oz.	1-96	1-230	½ *min.*, panting respiration, and almost complete paralysis. 2½ *min.*, convulsions, which recurred every few seconds till the 5th *min.* They were sometimes clonic, and sometimes tonic. The animal lay quiet till the 11th *min.*, when there was another convulsion. 13 *min.*, convulsion, marked reflex excitability. 65 *min.*, slight convulsion.	Nicotin, ♏ 1-230, was followed by difficult respiration and powerful tetanic convulsions. At 18 *min.*, entire recovery.
28	11¼ oz.	1-96	1-230	1 *min.*, panting respiration, semi-paralysis. 1½ *min.*, violent convulsions, after which respiration temporarily ceased, then recommenced with a gasp. Prolonged exhaustion.	Nicotin, ♏ 1-230, caused difficult respiration and semi-paralysis, but no convulsions.
29	10¼ oz.	1-96	1-230	Same as in Experiment 23.	Nicotin, ♏ 1-230, produced same effects as in Experiment 28.
30	10¼ oz.	1-96	1-176	1 *min.*, irregular convulsions, followed by difficult respiration and prostration. 35 *min.*, severe irregular convulsions, followed by marked increase of reflex excitability. 75 *min.*, marked tetanic convulsion. 2¼ *hrs.*, there have been occasional convulsive movements, but at no time paralysis.	Nicotin, ♏ 1-176, had been given alone 1 week previously. It had caused severe convulsions, but the animal had recovered in 1 *hr.*

The effects of fatal doses of Strychnia Sulphate, injected with, or followed by, varying doses of Nicotin ; and of fatal doses of Nicotin, injected with, or followed by, varying doses of Strychnia Sulphate, were next noted. The results are given in the following table. It will be noticed, that in some cases either drug was given in divided doses, and that, in these cases, the total amounts given are mentioned in the appropriate column.

Table III.

Experiments in which Nicotin and Strychnia Sulphate were given together, or at short intervals, Fatal or nearly Fatal Doses of either Drug being employed.

No.	Weight of Rat.	Dose of Strychn. Sulph. in parts of a grain.	Dose of Nicotin in parts of a Minim.	Result.	Symptoms, &c.
31	8 oz.	1–48	1-2000	Death.	After 1 *min.* the animal stood quiet, breathing with great difficulty. Occasional convulsive jerks were noted, and at 20 *min.* a tetanic convulsion (with emprosthotonos) and death.
32	8⅛ oz.	1–48	1-1000	Death.	The animal stood quietly, breathing somewhat heavily, until 30 *min.*, when there was a tetanic spasm, and death.
33	5 oz.	1–44	1-1000	Death.	After 3 *min.*, difficult respiration, and marked reflex excitability. 5 *min.*, slight convulsion, after which the respiration was slow and difficult, and the animal walked with great difficulty, and only when irritated. 15 and 27 *min.*, slight convulsions. 42 *min.*, tetanic convulsion, and death.
34	9½ oz.	1–48	1-800	Death.	1 *min.*, panting respiration. 5 *min.*, increased reflex excitability; prostration. 25 *min.*, tetanic convulsion, and death.
35	9½ oz.	1–31	1-800	Death.	The animal immediately lay on side paralyzed, and continued so till death, which followed an irregular convulsion at 2 *min.* The respiration was slow and gasping throughout.
36	6⅞ oz.	1–48	1-500	Death.	The nicotin was given in divided doses. ♏ 1-1000 was given with the Strychnia Sulphate. The rat stood quietly, breathing heavily until 12 *min.*, when there was convulsive trembling. An attempt to use the hypodermic syringe caused a convulsion. Nicotin, ♏ 1-2000, was now injected. At 20 *min.*, a second tetanic convulsion occurred, and immediately after Nicotin, ♏ 1-2000 was injected. At 22 *min.*, tetanic convulsion, and death.
37	5⅝ oz.	1–48	1-500	Death.	Immediately, almost complete paralysis, and panting respiration. From 1½ to 4 *min.*, continuous opisthotonos, with exceedingly rapid vibrations of the extremities. The respiration became slower and slower; at times, intervals of 10 sec. passed between the respiratory acts. 4 *min.*, slight convulsive motions. 7 *min.*, slight voluntary motions. Increased reflex excitability. Convulsions at 22, 34, and 37 *min.*, then death.
38	9¼ oz.	1-48	1-500	Death.	Nicotin given in divided doses, as detailed below. 5 *min.* after injection of Strychnia Sulphate, no effect was apparent, except increased reflex excitability. Nicotin, ♏ 1-1000, was injected. 10 *min.*, the rat is inactive; respiration somewhat labored. Increased reflex excitability. Nicotin, ♏ 1-1000, was injected. The respiration immediately became more difficult; the animal staggered, fell on side, and, at 13½ *min.*, had a violent tetanic spasm (emprosthotonos), terminating in death.
39	6⅞ oz.	1–48	1-800	Death.	The animal stood quietly, breathing heavily. 5 *min.*, almost helpless; marked reflex excitability. 13½ *min.*, tetanic spasm, and death.
40	9¾ oz.	1–48	1-400	Death.	Difficult respiration, increased reflex excitability, and almost complete paralysis, till 22 *min.*, when there was a single tetanic spasm, and death.
41	10¼ oz.	1-48	1-600	Death.	½ *min.*, difficult respiration; stands motionless, or moves with difficulty, if disturbed. 15 to 18 *min.*, slight convulsions. 25 *min.*, tetanic convulsion, and death.

TABLE III.—CONTINUED.

No.	Weight of Rat.	Dose of Strychn. Sulph. in parts of a grain.	Dose of Nicotin in parts of a Minim.	Result.	SYMPTOMS, &c.
42	10 oz.	1-96	1-220	Death.	The Nicotin was first injected; immediately after, difficult respiration, and semi-paralysis. 6 *min.*, irregular convulsions which terminated in cessation of respiration for 15 sec., when it re-commenced with a gasp. There was now complete paralysis (excepting of course the heart and respiration). At 25 *min.*, the animal was beginning to recover power, when Strychnia Sulphate, gr. 1-96, was injected. 43 *min.*, increased reflex excitability. 50 *min.*, tetanic convulsion, and death. *Post mortem*—The heart was exposed; it continued to beat for 10 min.
43	7 1/8 oz.	1-96	1-200	Death	Immediately, violent convulsions, lasting one min., followed by temporary cessation of respiration, which recommenced with a gasp. Almost complete paralysis till 23 *min.*, when the convulsions recurred, and terminated in death.
44	6 oz.	1-192	1-200	Death.	The Nicotin was first injected; it was followed in ½ *min.* by a tetanic convulsion, lasting 2 *min.*; then semi-paralysis. 4 *min.*, Strychnia Sulphate, gr. 1-192, was injected. 10 *min.*, the semi-paralyzed condition continued. Reflex excitability increased. 14 *min.*, tetanic, alternating with clonic, convulsions commenced, and lasted for 8 min., after which there was almost complete paralysis 33 *min.*, tetanic convulsion, and death.
45	8 1/2 oz.	1-96	1-130	Death.	Convulsions for 5 *min.*, succeeded by semi-paralysis, and increased, reflex excitability, with extreme difficulty in respiration. 2 *hrs.*, slight voluntary motions. 20 *hrs.*, almost complete paralysis; no convulsions. 21 *hrs.*, complete paralysis; slight convulsive movements occasionally. 23 *hrs.*, death from failure of respiration, which had become very infrequent (one a minute).
46	9 1/2 oz.	1-96	1-125	Death.	1 *min.*, tetanic convulsion, lasting 2 *min.*, and followed by semi-paralysis and difficult respiration. 28 *min.*, tetanic convulsion, and death.

B. *On Cats.*

As in the preceding series of experiments, the minimum fatal dose and the physiological effects of the two poisons were first ascertained.

I. *Minimum Fatal Dose of Strychnia Sulphate on Cats.*

This was found to be about 1-425 of a grain to the pound. It is probable, however, that age and individual peculiarities produce variations in the effects of this and other poisons.

TABLE IV.

Indicating the Minimum Fatal Dose and Physiological Effects of Strychnia Sulphate on Cats.

No.	Weight.	Dose of Strychnia Sulphate in parts of a grain.	Result.	SYMPTOMS.
47	7¼ lb.	1-16	Death.	A single convulsion caused death in 5 *min.*
48	1¼ lb.	1-30	Death.	A single convulsion caused death in 5 *min.*
49	3¼ lb.	1-30	Death.	In 13 *min.*
50	5¾ lb.	1-60	Death.	In 75 *min.*
51	5 lb. 15½ oz.	1-96	Recovery.	After 22 *min.*, panting, labored respiration. Great reflex excitability; slight convulsions, when disturbed; when not disturbed, sat motionless. After 1 *hour*, recovered.
52	3 lb.	1-144	Recovery.	In 15 *min.* extremely violent convulsions, lasting 2 *min.* Then the animal lay motionless on its side for 10 *min.*, and then was able to move, but with great difficulty. Convulsions occured at 47, 67, and 85 *min.*
53	2 lb. 14 oz.	1-192	Death.	After 15 *min.* a single tetanic convulsion, and death.
54	2 lb. 1 oz.	1-210	Recovery.	Marked reflex excitability and difficult locomotion.
55	2 lb. 1 oz.	1-240	Recovery.	No effect.
56	1 lb. 13 oz.	1-280	Recovery.	Marked reflex excitability; locomotion almost impossible for 1 hour.
57	1¼ lb.	1-280	Death.	In 19 *min.*
58	1 lb. 14 oz.	1-280	Recovery.	Barely escaped with life, after several severe convulsions.
59	1½ lb.	1-300	Death.	In 25 *min.*
60	1½ lb.	1-330	Recovery.	Barely escaped with life, after severe convulsions.
61	1 lb. 11 oz.	1-373	Recovery.	Slight rigidity of extremities, lasting 1 hour.
62	1 lb. 14 oz.	1-560	Recovery.	Slight rigidity of extremities.
63	½ lb.	1-400	Death.	After several hours.
64	2 lb. 3½ oz.	1-200	Death.	After two convulsions, in 50 *min.*

II. *Minimum Fatal Dose and Physiological Action of Nicotin on Cats.*

The least fatal dose was found to be about 1-150 of a minim to the pound. The physiological effects do not materially differ from those observed in rats. An additional symptom is extremely violent vomiting, due to gastro-intestinal spasm. (*Nasse.*)

TABLE V.

Showing the Effects of Nicotin on Cats, and the Minimum Lethal Dose.

No.	Weight of Cat.	Dose of Nicotin in parts of a Minim.	Result.	SYMPTOMS.
65	5 lb. 15 oz.	1–30	Recovery.	Respiration slow and labored for ½ *min.* then rapid and panting. Twitching of the ears. Disinclination to move. 45 *min.*, recovering.
66	8 lb.	1–20	Recovery.	The animal moved rapidly around the room for 9 *min.* Then vomiting occurred, and was followed by violent retching. He uttered incessant cries, and walked around, but less actively. The respiration was slow and panting: the pupils contracted. 20 *min.*, he walks with difficulty, having imperfect control over the posterior extremities. 1 *hour*, recovering.
67	8 lb.	1–19	Recovery.	Before the injection, the pulse was 150, and the respiration 51, a minute; the pupils were 9-20 in. in diameter. 2 *min.*, walks with great difficulty. Cries out anxiously. Purging and salivation. Respiration 45, noisy and difficult. Pupils 8-20. 8 *min.*, lay stretched out on side. Respiration 150. Pupils 7-20; nictitating membrane drawn over eye. 12 *min.*, walks with great difficulty, when disturbed. Respiration extremely rapid and panting. 27 *min.*, moves head, when tail is pinched, but cannot move rest of body. 37 *min.*, convulsive twitching of ears. 45 *min.*, paralysis and complete unconsciousness. Respiration 84. Pupils 10-20. 123 *min.*, recovering.
68	8 lb.	1–18	Death.	Before the experiment, respiration 36; pulse 156; pupils 10-20. 1 *min.*, respiration 30, very labored. 2½ *min.*, respiration 66, whistling; cried out; ears twitched; salivation. 4 *min.*, respiration 144; pupils 4-20; violent retching, purging. The animal lay apparently powerless, but moved, though with great difficulty, when disturbed; the extremities were quite rigid. No convulsive movements were apparent, except in the ears, but all the muscles (especially the masseters) could be felt rapidly vibrating. 12 *min.*, entire paralysis; legs jerked. 13 *min.*, respiration 63, noiseless; slight clonic convulsion. The respiration now became more and more infrequent, and finally ceased at 15 *min.* The heart beat five minutes longer. The pupil just before death was 8-20.
69	5 lb. 6 oz.	1–30	Death.	Before the experiment, the respiration was 57, the pupil 9-20. 1 *min.*, respiration 120, panting. 2 *min.*, lay on side; ears twitched; violent retching. 7 *min.*, respiration 45, not noisy, but very laborious; pupils 8-20. 11 *min.*, walked a few paces, with great difficulty. 12 *min.*, irregular convulsions, lasting ½ minute, and ending in death, through failure of respiration. The heart continued to beat for a few minutes.
70	3 lb.	1–60	Death.	Difficult respiration; vomiting, purging, and urination; tetanic convulsions, and death at 7 *min.*
71	3 lb. 9 oz.	1–35	Death.	Immediately on termination of injection, tetanic convulsions set in, and lasted for 1 minute, when the respiration ceased.

III. *Effects of the Combined Action of Nicotin and Strychnia Sulphate on Cats.*

Experiment 72.

Strychnia Sulph. gr. 1-292 and Nicotin ♏1-40 were injected together into a cat, weighing 1 lb. 14½ oz. The animal immediately breathed noisily and with difficulty; the ears twitched rapidly. He walked around the room with great difficulty, and at 4 *minutes* fell over on the side convulsed, and shortly expired. The heart continued to beat for a time after respiration had ceased, and this was the case in all the subsequent experiments.

Experiment 73.

Strychnia Sulph. gr. 1-193 and Nicotin ♏1-20 were injected together into a cat, weighing 2 lbs. 5 oz. The symptoms were: rapid, noisy, labored respiration; violent retching, and purging; in 2 *minutes*, tetanic convulsion, and in 4 *min.* death. Convulsive movements of the muscles of the head continued for several minutes after death.

Experiment 74.

Strychnia Sulph. gr. 1-288 and Nicotin ♏1-70 were injected together into a cat, weighing 2 lbs. ½ oz. The symptoms were the same as in the preceding experiment. Death occurred at 5½ minutes.

Experiment 75.

Strychnia Sulph. gr. 1-130 and Nicotin ♏1-75 were injected together into a cat, weighing 3 lbs. 9 oz. ½ *min.*, the cat walked around the room, staggering; extremities stiff; respiration slow and panting. 3 *min.*, he lay motionless on the side, but was able to move slightly, if irritated. There was marked reflex excitability. The respiration was rapid and difficult. 6 *min.*, slight, momentary, clonic convulsion. The respiration now became more and more feeble and infrequent, and ceased at 12 *minutes*.

Experiment 76.

Strychnia Sulph. gr. 1-74 and Nicotin ♏1-40 were injected together into a cat, weighing 6½ lbs. 3 *min.*, he ran around, crying anxiously. The respiration was slow, panting, and labored. 4 *min.*, he lay over on the side occasionally, as if exhausted. Convulsive twitching of the ears, and violent vomiting and retching, now commenced. The membrana nictitans was drawn. 5½ *min.*, he lay stretched out, motionless, on the side, but could walk, though with great difficulty, when disturbed. 9 *min.*, clonic, succeeded by tetanic, convulsions set in, and caused death.

Experiment 77.

Strychnia Sulph. gr. 1-74 and Nicotin ♏1-30 were injected together into a cat, weighing 6 lbs. 6 oz. The usual difficulty of breathing, vomiting, and prostration, ensued. The pupil was contracted. At 6½ *min.*, feeble convulsions occurred, lasted ½ minute, and were succeeded by complete paralysis. Respiration ceased at 9 *minutes*.

EXPERIMENT 78.

Strychnia Sulph. gr. 1-96 and Nicotin ♏ 1-63 were injected together into a cat, weighing 5 lbs. 3 oz. After 5 *min.*, twitching of ears; panting, rapid, labored respiration: contracted pupils. These symptoms, together with violent vomiting, continued till 15 minutes: when, in addition, marked reflex excitability was noted. 17 *min.*, convulsive jerking, which continued at intervals until 37 *min.*, when a violent tetanic convulsion occurred, and killed the animal. The symptoms, up to 15 *min.*, were those peculiar to Nicotin; then the convulsive action of Strychnia showed itself, increased, probably, by the identical action of Nicotin. At no time was there paralysis: the dose of Nicotin was not large enough to produce this symptom.

EXPERIMENTS 79, 80, 81.

(79) A cat weighing 2 lbs. 3 oz. received Strychnia Sulph. gr. 1-288. No symptoms resulted.

(80) The same animal, one week afterwards, received Nicotin ♏ 1-86. The symptoms lasted about one hour, and were as follows: violent vomiting, staggering gait, contracted pupils, twitching of the ears, and rapid, noisy respiration.

(81) The same animal, one week afterwards, received, by a single injection, Strychnia Sulph. gr. 1-288 and Nicotin ♏ 1-86. The respiration immediately became rapid and labored. In 30 *seconds* clonic convulsions commenced, and lasted till death, which occurred at 2 *minutes*.

EXPERIMENTS 82, 83.

(82) A kitten, weighing 1 lb. 12 oz., received Strychnia Sulph. gr. 1-384. 27 *min.*, a tetanic spasm occurred, and lasted one minute. The animal then lay perfectly motionless, with panting respiration, for 5 minutes; and afterwards rapidly recovered.

(83) The same kitten, one week afterwards, weighing 1 lb. 14½ oz., received Strychnia Sulph. gr. 1-384, together with Nicotin ♏ 1-100. After 1 *min.*, the animal breathed laboriously, and walked with difficulty. 2 *min.*, twitching of ears, violent vomiting. 3 *min.*, respiration very labored and noisy. Limbs very stiff. Vomiting continues. 15 *min.*, convulsions, somewhat tetanic; death at 17 *min.*

EXPERIMENTS 84, 85.

(84) A cat, weighing 6 lbs. 5 oz., received Strychnia Sulph. gr. 1-96. No result ensued, except slight increase of reflex excitability.

(85) The same animal, 20 days afterwards, weighing the same, received the same dose of Strychnia Sulph., together with Nicotin ♏ 1-50. The respiration immediately became difficult, then panting. 8 *min.*, twitching of ears. 9 *min.*, retching. 10 *min.*, the animal became convulsed, and in this condition leaped high in the air, then ran around the room, and at 11 *minutes* dropped dead.

EXPERIMENTS 86, 87, 88.

(86) A cat, weighing 6½ lbs., received Strychnia Sulph. gr. 1-82. No symptoms ensued, except temporary stiffness in walking.

(87) The same animal, one week afterward, received Nicotin ♏1-30. The symptoms were: very difficult respiration; twitching of the ears; vomiting and purging; marked prostration. After 1½ hrs., the animal began to recover.

(88) The same animal, one week after the last experiment, received together Strychnia Sulph. gr. 1-82 and Nicotin ♏ 1-30. After 1 *min.*, difficult respiration, and twitching of the ears. 3 *min.*, violent vomiting, purging, and urination. The animal lay over on the side, breathing very noisily. 12 *min.*, tetanic convulsion, and death.

C. *On Rabbits.*

I. *Minimum Lethal Dose of Strychnia Sulph. on Rabbits.*

This has been determined by Bennett, as regards the pure alkaloid, to be 1-288 of a grain to the pound. Of course, the dose of the sulphate must be proportionally greater.

II. *Minimum Lethal Dose and Physiological effect of Nicotin on Rabbits.*

The minimum fatal dose was found to be about 1-80 of a minim to the pound, or 1-27 of a minim to a rabbit of average size (3 lbs.). The essential symptoms caused by Nicotin, as in the cases of cats and rats, are paralysis and convulsions, with profound disturbance of respiration. Vomiting does not occur; purging and urination are not as common symptoms as they are in the cat. Rabbits are generally killed by a single convulsion, whether caused by Nicotin or Strychnia.

TABLE VI.

Showing the Effects of Various Doses of Nicotin on Rabbits, and Indicating the Least Fatal Dose.

No.	Weight.	Dose of Nicotin in parts of a Minim.	Result.	SYMPTOMS.
89	3 lb. 4¼ oz.	1-60	Recovery.	After 10 *min.*, the animal was somewhat languid, and rested at full length. 1 *hour*, perfect recovery.
90	3 lb. 13 oz.	1-54	Recovery.	Temporary weakness. Contraction of the pupil.
91	3 lb. 2 oz.	1-30	Recovery.	After 10 *min*, languid. After 20 *min.*, dragged hinder legs somewhat when walking. After 30 *min.*, ceased to drag hinder legs, but walked as if they were somewhat stiff. Pupil contracted.
92	3 lb. 4¼ oz.	1-18	Recovery.	Temporary prostration, contraction of pupil.
93	3 lb. 1 oz.	1-15	Recovery.	After 3 *min.*, languid. The posterior extremities were dragged somewhat in walking, then were moved altogether, as if they were stiff. Pupils contracted. 15 *min.*, the animal moved around in a small circle. There were jerking movements of the body, which lasted a few seconds, and were succeeded by extreme prostration, without actual paralysis. After 45 *min.*, recovering.

TABLE VI.—CONTINUED.

No.	Weight.	Dose of Nicotin in parts of a Minim.	Result.	SYMPTOMS.
94	3 lb. 2 oz.	1-42	Recovery.	Temporary prostration and contraction of pupil.
95	3 lb. 4¼ oz.	1-30	Recovery.	After 7 *min.*, paralysis of hinder extremities, and shortly afterwards of anterior extremities. The paralysis continued until 30 *min.*, when if disturbed the animal could move a short distance, on her belly, all the limbs extended sideways. Rapid recovery ensued.
96	3 lb. 1 oz.	1-28	Recovery.	4 *min.*, she ran around the room, convulsed, screaming loudly and sharply. 1½ *min.*, rested quietly; panting respiration. 6 *min.*, ran around the room for ½ minute, convulsed, and screaming. After this she became paralyzed, and lay stretched out on the belly. Respiration rapid and labored. This condition continued till 43 *min.*, when she had so far recovered, that when disturbed she moved herself on her belly along the floor for about two feet, using the limbs as lateral paddles. 50 *min.*, rapidly recovering.
97	3 lb. 1 oz.	1-27	Death	She walked across the room, wabbling, and placed her head in a corner. At 1 *min.*, she squealed sharply; the ears began to twitch. She fell on her side, and was seized with violent clonic convulsions, which lasted until 4 *min.*, when death ensued. The pupil at 2 *min.* had contracted from 7-20 to 2-20. As with all experiments with nicotin, the action of the heart continued after respiration had ceased.
98	3 lb. 2 oz.	1-20	Death.	After 1 *min.*, she lost all power over the hinder extremities, and, immediately after, over the front ones. 3 *min.*, severe convulsions occurred, after which she lay quiet and motionless. 5 *min.*, she was lifted, and had a slight convulsion. 10½ *min.*, convulsions occurred, and were succeeded by complete paralysis. The respiration grew slower and feebler, and, at 23 *min.*, ceased.
99	3 lb. 13 oz.	1-14	Death.	1 *min.*, twitching of the ears, clonic convulsions. 3 *min.*, convulsions occurred, and were succeeded by paralysis of the entire body, excepting the head, since she moved the head and ears when the hind quarters were touched. 22 *min.*, convulsions set in violently, caused apparently by the irritation of a sudden noise. These continued at intervals until 34 *min.*, when one of them terminated in death. The respiration, from the beginning, was at times gasping, and at times comparatively easy.

III. *Effects of the Combined Action of Nicotin and Strychnia Sulphate on Rabbits.*

EXPERIMENTS 100, 101, 102.

(100.) A rabbit, weighing 3 lbs. 4¼ oz., received Nicotin ℥ 1 50. Slight difficulty in walking, with prostration, and contraction of the pupil, ensued. In *one hour*, the animal had perfectly recovered.

(101.) The same animal, 8 days after, received Strychnia Sulph. gr. 1-192. No result ensued.

(102) The same animal, 8 days after, received Strychnia Sulphate gr. 1-192, together with Nicotin ℳ 1-50. The symptoms were the same as in Experiment 100.

Experiments 103, 104, 105.

(103) A rabbit, weighing 3 lbs. 5 oz., received Nicotin ℳ 1-50, with the same result as in Experiment 100.

(104) The same animal, 8 days after, received Strychnia Sulph. gr. 1-128, with no effect.

(105) Eight days afterwards, the two doses were given together, with the same effect as when the Nicotin was given alone.

Experiments 106, 107, 108.

(106) A rabbit, weighing 3 lbs. 14½ oz., was given Nicotin ℳ 1-50, with the same effect as in Experiment 100.

(107) The same animal, one week after, was given Strychnia Sulph. gr. 1-109, with no effect.

(108) After 8 days, the two doses were given together, and produced prostration, stiffness, noisy and labored respiration, with increase of reflex excitability.

Experiments 109, 110, 111.

(109) A rabbit, weighing 3 lbs. 14½ oz., received Strychnia Sulph. gr. 1-74. In 15 *min.* was accidentally struck by a door, and had a tetanic convulsion. 28 *min.* Perfect recovery.

(110) The same rabbit, 8 days afterwards, received Nicotin gr. 1-35. 3 *min.*, stiffness; difficult respiration. 15 *min.*, limbs almost completely paralyzed. 1½ *hour*, recovery.

(111) The same rabbit, after an interval of one week, received the two doses combined. After 2 *min.*, walked with difficulty; respiration labored. 10 *min.*, sat quiet, quivering occasionally. 35 *min.*, tetanic convulsion, and death.

Experiments 112, 113, 114.

(112) A rabbit, weighing 3 lbs. 11½ oz., received Strychnia Sulph. gr. 1-96, alone, and with no result.

(113) The same animal, 7 days afterwards, received Nicotin ℳ 1-30. Marked prostration and difficulty in breathing resulted.

(114) After an interval of a week, the two doses were given combined. In addition to the symptoms mentioned under Experiment 113, a slight convulsion occurred.

Experiments 115, 116, 117.

(115) A rabbit, weighing 3 lbs. 11 oz., received Strychnia Sulph. gr. 1-82, with no result.

(116) The same animal received Nicotin ℳ 1-30, with the same results as in Experiment 113.

(117) After one week, the two doses were given combined. 2 *min.*, dif-

ficult respiration; prostration. 8 *min.*, he lay with the extremities stretched out, powerless, his nose touching the ground. 1 *hour*, convulsive jerking. 70 *min.*, tetanic convulsion. 71 *min.*, brief clonic convulsion. Recovery.

Experiments 118, 119, 120.

(118) A rabbit, weighing 3 lbs. 11½ oz., received Strychnia Sulph. gr. 1-77, with no effect.

(119) The same animal, received Nicotin ♏ 1-30, with the same effect as in Experiment 113.

(120) One week after, the above-mentioned doses were given together to the same animal. For 22 *min.*, nothing was noted, except difficult locomotion, and prostration. Then two clonic convulsions occurred, in quick succession. 30 *min.*, clonic convulsion. 31 *min.*, tetanic convulsion, and death.

D. *On Dogs.*

Effects of the Combined Action of Nicotin and Strychnia Sulphate on Dogs.

Experiment 121.

A dog, weighing 2 lbs. 3 oz., received Strychnia Sulph. gr. 1-96. After 12 *min.*, the only symptom noticed was stiffness in walking. Nicotin ♏ 1-400 was now given; immediately, the stiffness of the extremities became so marked that it was almost impossible for the animal to walk. He lay down on his side, and, at 14 *min.*, had a violent clonic convulsion, lasting 1½ minute. At 15½ *min.*, Nicotin ♏ 1-400, was again injected. The animal continued to lay on the side powerless; the respiration became more and more feeble; there was convulsive twitching of the body: and death ensued, at 24 *min.*

Experiment 122.

A dog, weighing 4½ lbs., received Strychnia Sulph. gr. 1-72. 3 *min.*, no symptoms. Nicotin ♏ 1-400 was given. 6 *min.*, respiration labored, panting. 9 *min.*, he is very stiff; respiration the same. Nicotin ♏ 1-400 was again injected. 11 *min.*, irregular convulsions, during which Nicotin ♏ 1-400 was injected. The convulsion ceased at the 12*th min.*, but the animal still lay extended on the side, the respiration became less and less frequent, and ceased at the 14*th min.*

Experiment 123.

A dog, weighing 6½ lbs., received Strychnia Sulph. gr. 1-32. 6 *min.*, no symptoms. Nicotin ♏ 1-200 was now injected. The respiration immediately became somewhat labored. 13 *min.*, tetanic convulsion. Nicotin ♏ 1-200 injected. Immediately after the injection, a second tetanic convulsion occurred; shortly afterwards, a third. 16½ *min.*, death.

Experiment 124.

A dog, weighing 2½ lbs., received Strychnia Sulph. gr. 1-192, and Nicotin ♏ 1-96, by a single injection. 30 *seconds*, slow, panting respiration.

Pupils contracted; nictitating membrane drawn over the cornea. 35 *seconds*, he staggered a few steps, fell on the side, and in 1½ *min.* was seized with powerful tetanic convulsions, which terminated life at 4 *min.*

Experiment 125.

A dog, weighing 7 lbs., received Strychnia Sulph. gr. 1-32, with Nicotin ♏1-200. 1 *min.*, labored respiration. 7 *min.*, slight convulsion. 7½ *min.*, Nicotin ♏1-200 given. 8 *min.*, respiration labored and noisy. 9 *min.*, tetanic convulsion. 10 *min.*, Nicotin 1-200 given. 14 *min.*, tetanic convulsion, and death.

Experiments 126, 127, 128.

(126) A dog, weighing 2 lbs. 10 oz., received Strychnia Sulph. gr. 1-192. The symptoms were rigidity of the limbs, and slight increase of reflex excitability, lasting till the 25*th min.*

(127) The same animal, 5 days afterward, received Nicotin ♏ 1-192. The symptoms (which lasted about 20 minutes) were slow, labored respiration, staggering gait, vomiting, salivation, contracted pupil.

(128) The same animal, after 7 days, received the two drugs together, in the doses detailed above. The symptoms were slow, labored respiration, great weakness, staggering walk, vomiting, salivation, contraction of pupil; several slight convulsions between the 12th and 18th *mins.* 20 *min.*, recovery.

Experiments 129, 130, 131.

(129) A dog, weighing 7 lbs., received Strychnia Sulph. gr. 1-48. It was followed by stiffness and increased reflex excitability. When irritated, feeble convulsions occurred.

(130) The same animal, after 5 days, received Nicotin ♏1-200. 2 *min.*, respiration very difficult; gait staggering. 7 *min.*, purging and vomiting.

(131) The same animal, 7 days afterwards, received the doses, detailed in Experiments 129 and 130, combined. 2 *min.*, difficult respiration, and staggering gait. 9 *min.*, vomiting; great rigidity. 12 to 20 *min.*, irregular convulsions occurred spontaneously; gradual recovery.

Experiments 132, 133, 134.

(132) A dog, weighing 5 lbs. 10 oz., received Strychnia Sulph. gr. 1-96. 15 *min.*, decided stiffness and difficulty in walking; somewhat labored respiration. 28 *min.*, recovering.

(133) The same animal, 6 days afterwards, received Nicotin ♏1-200, with the same effect as in Experiment 130.

(134) The same animal, 7 days afterwards, received the two poisons combined in the doses detailed above. 1½ *min.*, difficult respiration. 7 *min.*, stiffness. 8 *min.*, vomiting; convulsive movements. 12 and 15 *min.*, irregular convulsions. 32 *min.*, recovering.

Experiments 135, 136, 137.

(135) A dog, weighing 2¾ lbs., received Strychnia Sulph. gr. 1-180, with the effects mentioned in Experiment 126.

(136) The same dog, 6 days afterwards, received Nicotin ℳ 1-192, with the effects described in Experiment 127.

(137) The same animal, 2 weeks afterwards, weighing then 4½ lbs., received the two poisons combined, in the doses mentioned in the two preceding experiments. 1 *min.*, panting respiration. 4 *min.*, lay quietly, as if exhausted. 12 *min.*, vomiting. 29 *min.*, decided rigidity. He stood with his head in a corner, moaning. Though the animal had much increased in weight, the symptoms were more marked than in the controlling experiments.

Experiments 138, 139, 140.

(138) A dog, weighing 11 lbs., received Strychnia Sulph. gr. 1-48, with no effect.

(139) The same animal, after 6 days, received Nicotin ℳ 1-20. 1 *min.*, difficult respiration. 2 *min.*, staggering gait. 15 *min.*, recovering.

(140) The same animal, 7 days after, received Nicotin ℳ 1-20. Immediately, the animal became almost completely paralyzed, and breathed noisily and laboriously. 1 *min.*, Strychnia Sulph gr. 1-96 was injected. Clonic convulsions set in after a few seconds, and continued for 1½ minute. During the convulsion, a second injection of Strychnia Sulph. gr. 1.96 (making in all gr. 1-48) was given. 2½ *min.*, convulsions ceased; temporary cessation of respiration, which recommenced with a gasp, and for 5 minutes was very laborious and infrequent (5 to 10 per minute). During this time, the animal remained completely paralyzed and unconscious. 7½ *min.*, he staggered across the room; respiration improving; pupil contracted, and nictitating membrane drawn. 21 *min.*, the animal now stood in a stiff, uneasy attitude, quivering very much when touched, and every minute running across the room, howling, slightly convulsed. 38 *min.*, he was lifted slightly with the foot, and fell over on his side in a violent clonic convulsion. After this, no more convulsions occurred. The animal gradually recovered.

Experiment 141, 142, 143.

(141) A dog, weighing 14 lbs., received Strychnia Sulph. gr. 1-24. It was followed by marked increase of reflex excitability, lasting 75 minutes. The animal barely escaped a convulsion.

(142) The same animal, one week after, received Nicotin ℳ 1-20, with the effects noted under Experiment 139.

(143) The same animal, one week after, received the two poisons combined, in the doses just detailed. 5 *min.*, difficult respiration, great rigidity, vomiting. 15 *min.*, severe clonic convulsions lasting two minutes. 23 to 35 *min.*, he had numerous convulsions, but none strong enough to cause him to fall. Then a powerful tetanic convulsion occurred; then the same condition of semi-convulsion was noted; and at 45 *min.*, another tetanic convulsion, and death.

Remarks.

The recorded cases of Strychnia poisoning treated by Tobacco are extremely unsatisfactory. If they prove anything, it is merely that Tobacco is a powerful emetic.

Haughton's experiments on this subject (really only two in number) were performed in such an unscientific manner as to be utterly valueless.

Wormley's and Reese's experiments would certainly seem conclusive, were it not for the fact that the drugs were administered by the mouth: therefore, since vomiting so generally occurred, we cannot feel certain that the tobacco infusion was absorbed with sufficient rapidity, or in sufficient quantity, to exert any possible antidotal power.

From the experiments given in detail in the preceding pages, the following inferences may, I think, safely be drawn:

1. Strychnia and Nicotin are in no degree antagonistic poisons.
2. Strychnia increases the convulsive action, and does not diminish the motor paralysis, of Nicotin.*
3. Nicotin (even in paralyzing doses) increases the convulsive action of Strychnia.†
4. Both poisons cause death by paralyzing the respiratory apparatus. They may effect respiration in different ways, but the result is the same.
5. Animals may be killed by injecting together doses of the two drugs, which, singly, are not fatal.‡

There is no reason to suppose that the above deductions are not applicable to the human animal. The symptoms of poisoning by the two drugs are identical in man and the lower animals. As regards Strychnia, this is too well known to need further remark. In regard to Nicotin, it is only necessary to refer the reader to the recorded cases of poisoning by that drug.§

It may not be out of place to mention the fact that experimentation has proven that Nicotin and Strychnia show a remarkable similarity in their intimate action on the nervous system, both being excitants of the spinal

* Exps. 25, 27, 28, 29, 30, 42, 43, 44, 45, 46, 88, 111, 131, etc.

† Exps. 81, 83, 85, 88, 114, 117, 128, 131, 140, 143, etc.

‡ Exps. 88, 111, 120, 143, etc.

§(1) A man, who had swallowed a mouthful of tobacco, became suddenly and completely *paralyzed; convulsions* set in; then *vomiting* and *purging;* and he finally died of exhaustion. (*Edin. Medical Journal*, Vol. I., p. 643.)

(2) A man received an enema of an infusion of two ounces of tobacco. In seven or eight minutes, he became pale and stupid; his speech was indistinct; and he complained of pains in the abdomen and head. There were *convulsive tremors*, first of the arms, then of the body. These symptoms were followed by *extreme prostration, and slow, laborious breathing;* then by coma, which terminated by death eighteen minutes after the poison had been injected. (*Tavignot, Gazette Med. de Paris*, Nov. 1840, p. 763.)

(3) Stillé gives the following symptoms in a case of poisoning by tobacco, in the person of a young woman: Slow respiration, coma, opisthotonos, with clonic convulsions of the extremities, dilated pupils. (*Therap. and Mat. Med.*, Vol. IV, p. 325.)

(4) A man sat over a chamber-pot containing some tobacco, on which hot

cord, and paralyzers of the motor or efferent nerves.* For the explanation of these assertions, and for many other deeply interesting facts connected with this subject, the reader is referred to other sources.

On the Brain of Coryphodon.

By E. D. Cope.

(*Read before the American Philosophical Society, March* 16, 1877.)

The character of the brain in *Coryphodon* being an important desideratum, I endeavored to obtain a cast of the cranial cavity of a well preserved skull of a *C. elephantopus*, from the Wasatch beds of New Mexico. The hard sandstone matrix which filled it, was removed with some difficulty; the more as its surfaces were indurated by a cement containing much iron oxide. The osseous walls were found in a good state of preservation. It was ascertained that there is a considerable *foramen lucerum posterius*, but which is not nearly of such proportionate size as that in the genus *Tapirus*.

The form of the brain-cast thus obtained is very remarkable. Its distinguishing peculiarities are, (1) the small size of the cerebellum; (2) the large size of the region of the corpora quadrigemina; (3) the small size of the hemispheres; and (4) the enormous size of the olfactory lobes.

There is in the cast a strong constriction in front of the *medulla oblongata* on one side, which does not exist on the other side. It is uncertain which represents the true form, as regards the lateral portion, but that there was a step-like constriction across the base of the brain at this point, there is no doubt. The medulla is very stout and wider than the hemispheres; it is depressed, and a protuberance on the inferior part of each side has the appearance of the base of the eighth pair of nerves. The region of the cerebellum is depressed and does not present in the cast a distinct line of demarkation from the medulla. An indication of the vermis is seen in a low longitudinal median protuberance. In front of this a transverse shallow depression separates it from the middle brain.

The region of the *corpora quadrigemina* is the most bulky portion of the

coals had been placed. After sitting a few minutes he became completely paralyzed, and showed no signs of life, except a deep sigh every fifteen or twenty seconds. (*London Med. Gaz.*, Oct. 1846, quoted by Stille, *Op. Cit.* p. 324.)

(5) Taylor states that in a case of suicide by nicotin, that the person "became insensible and powerless within a few seconds, and died in from three to five minutes; without convulsions."

A reference to the experiments related in the text, will show the entire similarity of the action of tobacco on man, to its action on the lower animals.

H. C. Wood's Therapeutics, pp. 284, 340, 341.

brain. Superiorly it presents a large transverse tuberosity, with the lateral portions well defined, but not distinguished from the cast of the hemispheres on the median line. From its latero-superior prominences it extends downwards and forwards on each side, expanding laterally and narrowing as it approaches the inferior surface. Each lateral portion is separated from the hemisphere by a deep fissure, into which a prominent crest of the lateral cranial walls projects. This crest commences above, nearly at the plane of the superior wall, and curves downwards and forwards to below the middle of the cavity which contained the hemispheres. The inferior face of the middle region of the brain is bounded laterally by the projecting masses above described, posteriorly by the constriction in front of the medulla, and anteriorly by a slight contraction marking the boundary of the hemispheres. Its anterior lateral angles are continued into a fossa of the cranium, which I did not clear of the matrix, but which doubtless gives exit to the *foramina sphenoörbitale* and *rotundum*. The protuberance which occupies this fossa here, includes the base of the trigeminus nerve. A short distance posterior to this position on the inferior side of the lateral expansion of the middle brain, is the slight projection which covers the cavities of the *foramen ovale* and the *foramen lacerum posterius*. Between these on the middle line, is a pair of longitudinal elevations divided by a median longitudinal depression. Posteriorly they rise from the transverse constriction of the medulla; anteriorly they terminate rather abruptly, the one half at a point anterior to the other. This assymmetry is found in the osseous basis cranii, and is not due to accident. This median ridge is separated by a wide, shallow concavity from the lateral border on each side. A short distance anterior to the *foramen sphenoörbitale* is a small fossa which I have not explored, but which is the opening of the *foramen opticum*. They are of small size, indicating a corresponding character for the optic nerve.

The *cerebral hemispheres* are relatively and absolutely very small, their median long diameter being one-fifteenth the total length of the skull, or a little smaller than those of the *Uintatherium mirabile*, according to the figures and description of Marsh. They are together about as wide as deep posteriorly, but both diameters diminish rapidly forwards, the vertical the most rapidly. The profile slopes downwards and forwards to the base of the broad olfactory peduncles. There are no convolutions nor any decided indication of the Sylvian fissure,* but there are surface-casts of the small arteries that ramified in the dura mater. Owing to the prominence forwards of the inferior part of the middle brain, but a small part of the inferior surface of the hemisphere is visible. The olfactory lobes are the largest known among *Mammalia*, and greatly exceed those of *Uintatherium*, as described by Marsh, and even those of *Oxyæna*. Their peduncle is transversely oval in section, and is directed horizontally forwards for a

* Prof. Marsh (Amer. Journ. Sci. Arts, 1876, p. 166) states that both convolutions and a Sylvian fissure are present in *Uintatherium*. These assertions are not justified by his figures, nor by the probably similar brain of *Coryphodon*.

distance about half as great as the length of the hemispheres without change of form. The mass then expands laterally and superiorly, rising upwards on each side of an osseous septum, which does not divide the olfactory lobes to the inferior face. They are thus deeply grooved above, and finally become furcate near to the extremity. Posterior to this point the inferior face rises, and the apices project laterally and forwards from the superior part of the lobe. The olfactory lobes consist, then, of a massive peduncle supporting a grooved subconical enlargement, which is bifurcate at the apex.*

Since the internal walls of the skull show the foramina for the exits of the cranial nerves, we have a sufficient basis for the determination of the parts of the brain. In this attempt we are met by the difficulties which are inherent in the use of a cast to represent a brain. Although the *foramina sphenoörbitale* and *rotundum* can be readily fixed, their position is such as to give the point of exit of the nervus trigeminus an unusually inferior position. This appears to be the case to a still greater extent in the *Uintatherium*,† where the lateral descending masses are at the same time not nearly so largely developed as in *Coryphodon*. The large inferior area enclosed between these boundaries is then homologous with the *pons varolii* or that part of the encephalon which is covered by it. Its appearance in *Uintatherium* supports this identification, but its proportions and anterior position in *Coryphodon* depart more widely from the usual form. The two anterior submedian ridges of its surface, faintly indicated in *Uintatherium*, may be the homologues of the pronounced median ribs in *Coryphodon* which resemble a continuation of the anterior pyramids of the medulla oblongata. As they are not very distinctly marked in the medulla of *Coryphodon*, their identification may be uncertain, but they look like that portion of the anterior pyramids which is continuous with the crura cerebri, and which are concealed in *Mammalia* by the pons varolii. Their prominence in *Coryphodon* indicates that the pons is wanting in this genus as in the *Reptilia*. A shallow concavity of the sphenoid bone between the origins of the trigemini indicates the position of a pituitary body or hypophysis.

In profile the brain closely resembles in form that of a lizard, *e. g.*, an *Amiva*, excepting that in the latter the cerebellum is more elevated. The extension downwards and forwards of the middle brain with its projection below the hemispheres is common to both, but the inferior portions at least, do not appear to be homologous in the two. In the *Coryphodon*, the lateral projections correspond with the exits of the trigeminus from the skull; in the *Amiva* this part terminates in the optic tracts. The superior portions of the middle brain correspond in appearance and relative size with that of the *Amiva*, but a clear difficulty in identifying them in the

* Measurements of this brain are given in the article on *Coryphodon elephantopus*, in my forthcoming report on the vertebrate Paleontology of New Mexico. Vol. IV, of the report of Lieut. G. M. Wheeler.

† See Amer. Journ. Sci. Arts, 1876, pl. iv, p. 165.

two types, is derived from the difference in their inferior connections. One result of the examination is assured, viz.: that this region is no part of the cerebral hemispheres, and that it is entirely uncovered by them. As it is not the cerebellum, it stands in the position of the corpora quadrigemina, or perhaps the posterior pair more especially. As the homologies of this region in the vertebrate brain are not yet determined, further attempts to identify this part of it in the *Amblypoda* must be postponed for the present. The structure is in any event entirely different from that seen in any recent *Mammalia*, or in any Mammal of a period more modern than the Eocene period, and one that not only entitles these animals to a position in a peculiar order, but also in a special division of the class, even more distinct than those based by Prof. Owen on the modifications of the structure of the brain. The homologies of the olfactory lobes are simple, but their extent and form resembles nothing known among mammals, even far exceeding in size those of *Uintatherium*. On the other hand, they resemble those of reptiles, especially of the lizards, but are less deeply bifurcate anteriorly than in them. In the *Coryphodon elephantopus* they equal in length the middle brain and hemispheres together, and their bulb equals the hemispheres in transverse and vertical diameter.

The nearest approach to the form of the brain in the *Amblypoda*, is seen in that of the *Arctocyon primævus*, a Creodont which represented the *Carnivora* in the same lower Eocene fauna, and was actually associated with *Coryphodon* in France. This brain is described and figured by Prof. Gervais, Nouv. Archives du Muséum, vi., 1870, p. 150, Pl. 6 f. 4, who notices the remerkable exposure of the middle brain or corpora quadrigemina. Among *Mammalia* of later ages some of the extinct South American *Edentata*, present the greatest resemblances, although slight ones. Among these may be noticed the small and transverse cerebellum, and especially the lateral expansion of the region anterior to it. To what portion of the brain this expansion belongs, is not known, but it is not unlike the lateral mass in *Coryphodon*, as, *e. g.*, in the *Eutatus seguini*,* Gervais. There is, however, nothing exposed on the superior surface in the Edentata which appears to be the middle brain; hence the difference from the brain of the *Amblypoda* is very considerable.

In reviewing the evidence brought together up to the present time, the writer is of the opinion that the type of brain shown to exist in the *Amblypoda*, and *Creodonta*, is as distinct from those characterizing the primary divisions of the *Mammalia*, as they are from each other; and that it necessitates the establishment of a special sub-class for their reception of at least equal rank with the groups *Gyrencephala*, *Lissencephala* and *Lyencephala*. This may be called *Protencephala*, with the following definition: Cerebral hemispheres smooth, small, leaving not only the cerebellum but the middle brain exposed behind, and contracting into the

*Figured in the important Memoir of Gervais, already quoted, Nouv. Arch. Mus., 1869, v., p. 42.

very large olfactory lobes in front. Cerebellum very small and flat; middle brain large. This character is sustained by that of the ankle joint, which, existing in two such distinct divisions as the *Amblypoda* and *Creodonta*, may be found to characterize the entire sub-class, but this is not yet certain; it is as follows: Tibio-astragalar articulation flat, and without groove or segment of pulley.

This sub class stands below the *Lyencephala* in its position, approximating the reptiles in the points above mentioned, more nearly than the latter do. It includes two orders, one ungulate, the *Amblypoda*, the other unguiculate, the *Bunotheria*.* To the former belong the sub-orders *Pantodonta* and *Dinocerata*; to the latter the *Creodonta* and probably the *Tillodonta* and *Taeniodonta*. Whether the *Mesodonta* belong to it is not certainly ascertained, while the *Insectivora* do not belong to it, as they are rightly placed in the sub class *Lissencephala*.

Lartet first pointed out the fact of the successive increase in the size of the brain of the *Mammalia* with the advance of Geologic time; and Marsh has stated that this increase is to be observed principally in the relative size of the cerebral hemispheres. I would correct the latter statement so far as to add, that the increase of size is to be seen in the cerebellum as much as in the hemisphere. It is also evident that the relative decrease is in the middle-brain and olfactory lobes.

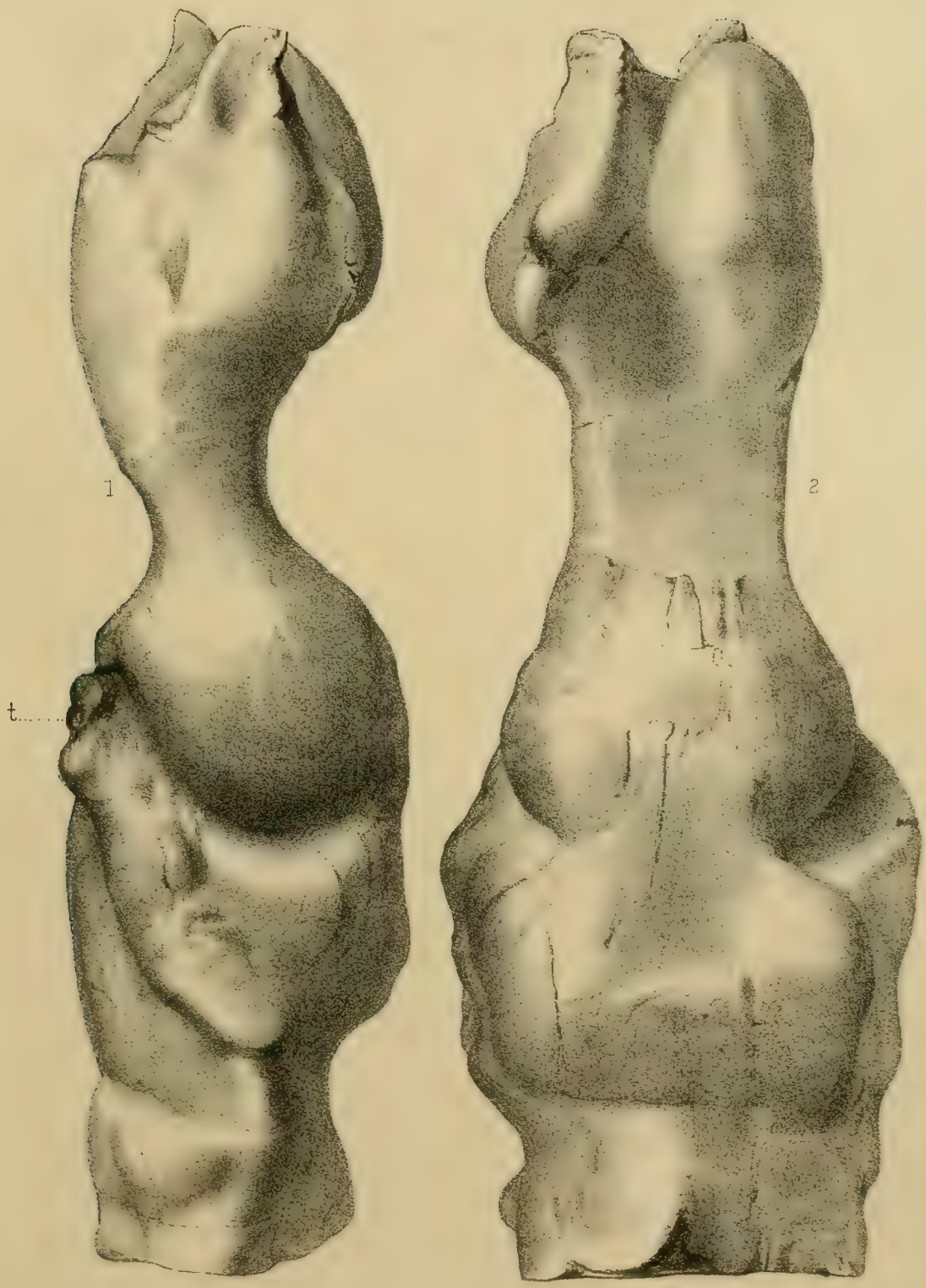
Explanation of Plates.

Pl. I. Cast of brain cavity of *Coryphodon elephantopus*, two-thirds the natural size. The right bulbus of the olfactory lobe is probably too large above, owing to the want of preservation of the superior wall of the cavity.

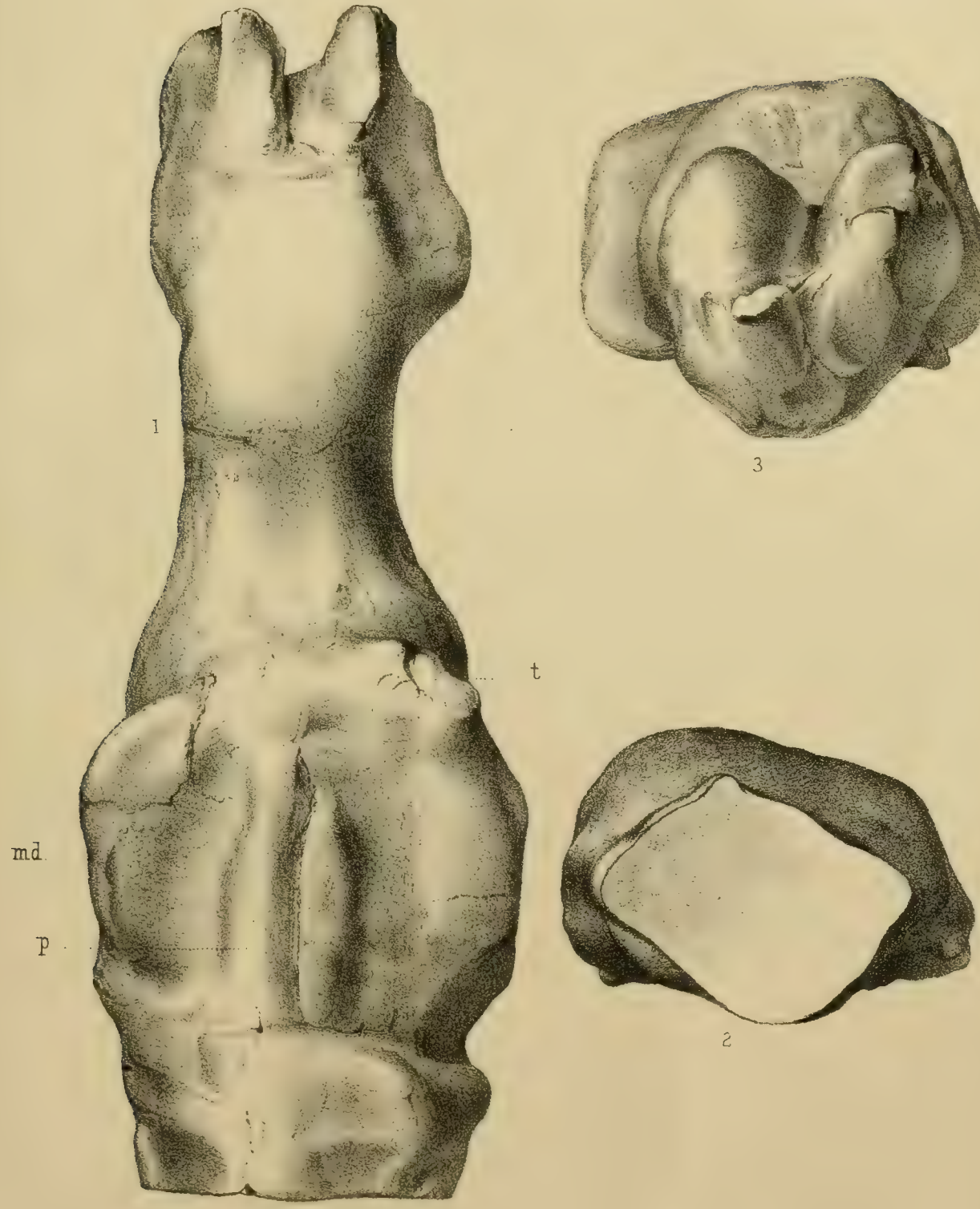
Fig. 1. Superior view; fig. 2, the left side: t. base of the trigeminus nerve.

Pl. II. The same. Fig. 1, from below; fig. 2, posterior; fig. 3, anterior views. t. base of the trigeminus nerve: md. base of the mandibular branch of the trigeminus; p, ribs continuous with anterior pyramids.

*See Proceedings Academy Natural Sciences of Philadelphia, 1876, p. 88.



Coryphodon elephantopus ½



Coryphodon elephantopus $\frac{2}{3}$

Contribution to Palæontology from the Museum of the Second Geological Survey of Pennsylvania.

By Charles E. Hall.

(*Read before the American Philosophical Society April* 6, 1877.)

Genus Eurypterus.

Eurypterus ; Dekay, Annals of the Lyceum of Natural History of New York, 1825, Vol. I, p. 375.

The geological horizon of Eurypterus has heretofore been confined to the Water-lime group, in the United States, although the genus has been recently discovered in the English coal measures.

The position of the Water-lime group is between the Onondaga salt group and the Lower Helderberg group, therefore Upper Silurian.

The Water-lime group in Pennsylvania is lithologically well defined, but has not yet, to my knowledge, furnished a single specimen of crustacea. In New York the group is characterized by the crustaceans Eurypterus, Pterigotus and Ceratiocaris.*

Bernician.

Eurypterus Pennsylvanicus (provisional. n. sp.)

In the collection of 1874, made under the direction of Mr. J. F. Carll, in Venango County, Pa., a perfect but indistinct carapace of an Eurypterus was found by his assistant Mr. Hatch.

The specimen agrees in general with Eurypterus remipes of the Water-lime.

Position and locality, in sandy shale overlying a sandstone, which is equivalent to the Garland Conglomerate, at Rooker Farm, Venango Co. Pa.

The horizon is in the transition series between the base of the *Carboniferous* and the top of the *Devonian.*

Carboniferous.

Genus Eurypterus.

Sub-genus Dolichopterus.

Dolichopterus Mansfieldi. (n. sp.)

Carapace semioral, wider than long, indented line visible along the anterior margin, lateral margins nearly straight for one-fourth the length, then evenly rounded ; eyes prominent, kidney-form, situated a little forward of the centre of the carapace and about midway between a medial line and the lateral margins.

Body convex, the middle of the thorax slightly wider than the carapace, length of the joints increasing towards the terminal spine-like prolongation.

* See N. Y. Palæontology, Vol. III.

Entire surface covered by small, triangular, imbricating scales, decreasing in size towards the lateral margins; along the anterior portion of the carapace the scales are not visible. The paletti (one of which is preserved) long and narrow, being nearly twice as long as wide, and has the characteristic serrated margin, which is the principal distinguishing feature in the sub-genus. Length of specimen, without terminal joint, two and three-fourths inches; greatest breadth seven-eighths of an inch.

Position and locality. Found in the shale immediately below the Darlington cannel coal, near Cannelton, Darlington Township, Beaver Co. Pennsylvania. Horizon, Alleghany River Series.

We are indebted to Mr. S. F. Mansfield, of Cannelton, for this beautiful specimen, and after whom we deem it proper to name the species.

On the Relative Ages of the Sun and certain of the Fixed Stars.

By Professor Daniel Kirkwood, of Indiana University.

(*Read before the American Philosophical Society, April* 6, 1877.)

The doctrine that the light and heat of the sun are produced by the chemical combination of its elements was very generally accepted till about the middle of the nineteenth century. It has, however, been completely disproved by the labors of Dr. Mayer and Sir William Thomson. The quantity of heat radiated by the sun in a given unit of time has been determined with approximate accuracy. The amount produced by the combustion of a given quantity of coal is also known. From these data it is easily shown that if the sun were a solid globe of coal, and a sufficient supply of oxygen were furnished to support its combustion, the amount of heat resulting from its consumption would be less than that actually emitted within historic times. "Take (in mass equal to the sun's mass) the most energetic chemicals known to us, and in the proper proportion for giving the greatest amount of heat by actual chemical combination; and, so far as we yet know their properties, we cannot see the means of supplying the sun's present waste for even 5,000 years."* The chemical theory is accordingly given up as wholly untenable.

What then is the source of solar energy? To this interesting question, in the present state of our knowledge, but one reply is possible. The great law of the conservation of force—one of the most important discoveries in the history of physical science—points at once to a cause which is adequate both in mode and measure. Motion may be transformed into heat, and *vice versa*. The heat produced by the fall of a given quantity of matter upon the sun from the outer limits of the solar system would be 7,000 times greater than that resulting from the combustion of its own weight of coal. In the mechanical theory of solar energy, as advocated by Helmholtz and

* Tait's Recent Advances in Physical Science, 2nd Ed. p. 152.

now generally accepted, the sun's heat is produced by the falling together or condensation of the matter of which its mass is composed. But the rate of solar radiation and also the mechanical equivalent of heat are known. With these as data it may be easily calculated that a contraction of the sun's radius amounting to one mile in 40 years would be sufficient to keep up the present supply of heat. At former epochs, when the volume was greater and the density less, a more rapid contraction was necessary to keep up the supply. If the sun, or rather the solar system originally existed as a nebulous mass, with a radius equal to half the distance of the nearest fixed stars, the total amount of heat generated by contracting to its present dimensions would have kept up a supply, equal to that now dispensed, for about 20 millions of years. This period, it will be observed, includes the entire physical history of the solar system, from Neptune down to Mercury. It must be liable however, to considerable uncertainty, as it assumes the radiation of heat to have been uniform.

Before attempting a comparison between the ages of the sun and certain of the fixed stars it should be premised that from the epoch of incipient solidification, or rather of incipient transition from the gaseous to the liquid form, the quantity of motion in the contracting mass, and consequently the amount of radiant heat, must gradually diminish. Many of the nebulæ and some of the fixed stars have not reached this epoch ; while the sun, 61 Cygni, and the companion of Sirius, as will be shown hereafter, have probably passed it. Our first comparison will be that of

The Sun and Alpha Centauri.

The larger component of the double star Alpha Centauri is of the first magnitude ; the smaller one, of the second. The color of both has been described as dark orange. According to Hind,* the system completes a revolution about its centre of gravity in 85 years ; the mean distance between the components being 23.49 times the radius of the earth's orbit—somewhat greater than the distance of Uranus from the sun.

Of all the fixed stars whose distances have been measured, Alpha Centauri is the nearest to us. Its annual parallax is $\frac{928}{1000}$ ths of a second, which corresponds to a distance 7336 times that of Neptune from the sun : —so completely isolated in space is our planetary system.

The apparent magnitude of Alpha Centauri is greater than that of any star in the Northern Hemisphere ; and of those South of the equator but visible in our latitude, Sirius alone surpasses it in splendor. Its mass is nearly the same with that of the sun ;† while the intrinsic light and heat of the system are nearly three times greater. It may be inferred from these facts that the sun has probably passed the epoch of greatest heat, and that it is farther advanced in its physical history, or, in other words, is an older star, than Alpha Centauri.

*Monthly Notices of the R. A. S. for January, 1877. These elements differ materially from those previously found.

†Hind's recent value is *greater* than the sun's mass; all former estimates *less*.

61 Cygni.

The annual parallax of 61 Cygni is $\frac{1}{10}$ths of a second, which corresponds to a distance 448,000 times that of the earth from the sun. The magnitudes of the components are 5½ and 6; their distance from each other is 45 times the radius of the earth's orbit; their period, about 500 years; and the sum of their masses, rather more than one third of the sun's mass. They have the same color—a golden yellow.

The mass of the larger component of 61 Cygni may be taken at one fifth of the sun's mass. According to the estimate of Sir William Herschel the light of an average star of the first magnitude is 50 times that of a star of the fifth, or about 75 times that of the larger component of 61 Cygni. The intrinsic light of the principal member of Alpha Centauri being twice that of the sun and 75 times that of A, 61 Cygni, we obtain the following relations:

	Sun.	A, 61 Cygni.
Surface, (densities equal?)	3	1
Mass	5	1
Intrinsic light	9½	1.

These numbers seem to indicate that 61 Cygni is farther advanced than the sun in its physical history.

Sirius.

"It has been long acknowledged," says Humboldt, "that of all the brightest luminous fixed stars of heaven, Sirius takes the first and most important place, no less in a chronological point of view, than through its historical association with the earliest development of human civilization in the valley of the Nile." The recent discovery of its binary character, together with the determination of its parallax, mass, motion, and constituent elements, have greatly enhanced the interest with which this star is regarded by the scientific public. From the meridian altitudes of Sirius, as observed by Sir Thomas Maclear, at the Cape of Good Hope during the years 1836 and 1837, Dr. Gylden, of Pulkowa, has found its annual parallax to be $\frac{1}{10000}$ths of a second, which corresponds to a distance 1,068,700 times that of the sun from the earth. The light of this star is therefore 16 years in reaching us.

The orbit of this binary system has been computed by Dr. Auwers, who finds the period of revolution to be 49 years and 146 days; the semi-axis major, 37 times the distance of the earth from the sun; and the eccentricity, 0.6148,—somewhat greater than that of Fays's comet. The mass of the companion is half that of the principal star; or more accurately, the mass of Sirius is 13.76, and that of the telescopic star, 6.71, the mass of the sun being unity. According to the photometrical experiments of Sir John Herschel, the light received from Sirius exceeds that of Alpha Centauri in the ratio of 25 to 6. Comparing, therefore, the distances of the two stars, we find the intrinsic light of Sirius to be 93 times that of Alpha Centauri.

or 279 times that of the sun. The relative quantity of heat emitted by the different bodies may be assumed to have the same ratio.

But while the mass and distance of Sirius have been ascertained within moderate limits of error, the degree of its condensation, as compared with that of the sun, is still undetermined. On the hypothesis of equal density the light emitted from the sun would be but $\frac{1}{48}$ th part of that radiated from an equal portion of the star's surface. But, if equal areas of the two bodies afford equal quantities of light, then the volume of Sirius is 4661 times that of the sun, and the mean density of the latter is 333 times that of the former. It seems probable, therefore, that the principal component has still chiefly, if not entirely, a gaseous constitution.

As the light of Sirius, according to Sir John Herschel, is 324 times that of an average star of the sixth magnitude, and as the satellite discovered by Clarke is of the ninth or tenth magnitude, the light of the latter must be much less than one thousandth part of that received from the principal star. But according to Auwers the mass of the less component is equal to half that of the greater. Is it possible to explain these remarkable facts on the theory that the two bodies had a simultaneous origin in the same nebula, or has their present proximity resulted from the proper motions of two originally independent stars?

The conclusions apparently sustained by the facts here considered may be summarized as follows:

(1.) The history of the solar system is comprised within twenty or thirty millions of years.

(2.) From the fact of the larger component of Alpha Centauri radiates twice as much light as the sun while the mass of the former is *less* than that of the latter, we infer the probability that our solar system is the more advanced in its physical history.

(3.) 61 Cygni seems to have reached a greater degree of condensation than the sun, since, on the hypothesis of equal density, the surface of the larger member is one third that of the sun, while the intrinsic light is less than one ninth.

(4.) The companion of Sirius appears to have reached a stage of greater maturity than the sun, while the contrary seems to be true in regard to the principal star.

Bloomington, Indiana, March 26, 1877.

THE TIMUCUA LANGUAGE.

By Albert S. Gatschet.

(*Read before the American Philosophical Society, April* 6, 1877.)

The science of linguistics, glottics, or as it was at first called, of comparative philology, is of very recent date. Classical antiquity ignored it and it became a science only through the introduction of Sanscrit into the circle of those time-honored languages, of which the study was considered of importance. Modern geography, history, archæology and ethnology then availed themselves conscientiously and with signal success of this new help. One of the greatest triumphs obtained by linguistics is the disclosure of the primordial social state of the Semitic race and of our remotest Indo-European ancestors. Undoubtedly the antiquity of the two American continents could be disclosed by zealous scientists in the same manner, that is, by comparative researches on their languages, if reliable material is previously collected to a sufficient amount, so that the linguist can light his torch and proceed smoothly along the ethnological pathway of inquiry.

To similar researches I intend to furnish a small contribution by publishing some notices on the Timucua language, which is perhaps that idiom spoken within the present boundary of the Union in which the oldest writings of some extent have been published. As a nation, the Floridian Timucuas are now extinct, but their idiom is preserved in a shape which promises the possibility of its total restoration.

Historical and Ethnological Remarks.

At the time of its discovery the Floridian peninsula was inhabited by four principal and a number of minor nations, engaged in continual warfare among themselves. The Apalaches dwelt from the Suwannee River down to Tampa Bay; the southwestern coast was held by the ferocious Colusas, the southeastern parts and the Bahama Islands by the Tegestas, while nations speaking Timucua dialects extended from the neighborhood of Cape Cañaveral to the mouth of St. John's River and occupied many regions of the interior.

To avoid errors we must carefully distinguish between the three areas of territory to which the name Timucua is at present applied.

First, we have the area of the original Timucua tribe and of its dialect, around San Augustine. It is called by the early writers "Provincia timuquana."

Secondly, we have the area of a commonwealth of vassal chiefs centralized under one monarch, of which the above Timucua tribe formed a portion, and was probably its most powerful part. For want of another historical or more comprehensive name this oligarchic commonwealth or monarchy was called by the same name of Timucua.

Thirdly, we have the area of the *language stock*, to which the dialect of the Timucua tribe belonged. This area has probably extended far beyond

the limits of the Timucua monarchy, but at the present time it is not possible to state its domain even by a rough approximation.

The name is written by the Spanish chroniclers Timagoa, Timuca, Timucua, Timuaca; by French authors Thimagona; by the English Tomoco, Atimuca, and contains the word *atimoqua*, which occurs in Pareja's books, f. i. in the Confessionario, on page 205, meaning *lord, ruler.*

In the sixteenth century the native population of northeastern Florida was governed by small chiefs, each of them ruling with absolute power over one or a few settlements laid out in the shape of corrals. These diminutive princes (or *olata, holata*) depended from a monarch in the same manner as the vassals of mediæval times depended of their suzerain or liege lord. To judge from the numerous revolts against their supremacy, the rule of the Timucua suzerain must have been rather despotic and arbitrary. His title was Paracussi, and, when spoken of in his quality as war-chief, Urriparacussi, *urri* or *iri* meaning war. His residence on Lake George seems to have been stationary; the name given for it by the chroniclers, *Utina* or *Utinama*, simply means "my country," and when used for the King himself it is abbreviated from *Paracussi Utina.*

We are informed by Barcia (*Ensayo*, page 48) that at the time of Réné Laudonnière's expedition, in 1564, forty vassal-chiefs obeyed the commands of this ruler. The tribe or province of the Timagoa was then governed by the Cacique Mollave, and the natives represented his territory to be rich in precious metals. Mollave was the vassal of a mighty king, of whose real name we are not apprized, though his title is given as *Olata Otina*, in Spanish "Señor de muchos Señores." This monarch wielded his sceptre over forty sub-chiefs, and the names of the most powerful of them are given as Chadeca, Chililo, Echonobio, Enacapen, Calanio, Anachatagua, Uvitaque, Aequeya, Mocoço. A chief named Potano-u was then rebelling against the Olata Otina, who was himself warring against another monarch, Soturiba, the commander of thirty caciques or sub-chiefs, and was forced by him to a disastrous and sudden retreat.

The following local names were collected from various sources and though I cannot vouch for the correctness of their orthography, I believe all of them contain words from the Timucua language: *Itara, Potano, Cholupaha, Caliquen, Napetuca, Hapaluya, Axille* (*Ausile*), *Salamototo, Ajohica, Turahica, Alachua* (*Lachua*); and two river names: *Aquila* (reed, vine), *Ajano hibita chirico* (river of small acorns). Father Fr. Pareja quotes the provinces of *Mocama, Itafi, Timucua, Potano* and the "*Fresh-water-District.*" The westernmost town of the Timucua on the border of the Apalache country is given as *Asibe*, the easternmost of the Apalaches being *Ibitachuco.*

While it is difficult or impossible for topographers of our time to locate on our present maps most of the Floridian places mentioned in the sixteenth and seventeenth centuries, it is on the other side apparent that many local names surviving at the present time are of Indian origin, and that after obtaining a sufficient knowledge of the Timucua tongue we will be

enabled to trace the outlines of its ancient area through a careful analysis of these geographical terms.

Like the other Floridians, the Timucua were a people of large bodily proportions, lighter complexioned in the North, darker in the South, but exhibiting throughout that peculiar admixture to their cinnamon hue, which is called *olivâtre* by the French. For their subsistence they did not rely merely on the abundance of fish, eels and turtles, which peopled their rivers, ponds and lakes, but they also sowed the fields and hunted all sorts of game. Like other Indians they were addicted to polygamy, gross sensuality, sorcery and other superstitious practices, of which Pareja's books afford many curious examples. The population was divided in two portions, separated from each other in the strictest manner; the *nobility*, all of whose numerous pedigrees traced their origin to the sacred persons of the actual monarch or his predecessors, and the *common people*, which also preserved with piety the memory of its ancestors by long genealogical registers. No doubt an aristocratic spirit pervaded the civil and political institutions of these tribes, and if from this we are allowed to draw any conclusion referring to their antiquity, it would tend towards establishing a very protracted residence of the Timucua in these same regions, where the European explorers discovered them, and a comparative isolation and non-intercourse with surrounding nations.

For further ethnological information I refer to Dr. Dan. G. Brinton's "Notes on the Floridian Peninsula, its literary history, Indian tribes and antiquities, Phila. 1859," as well as to the writers on the ancient history of the country, as Basanier, Barcia, Bristock, Fontanedo, Herrera, Roberts, etc., and to the three chroniclers of the illustrious expedition of Hernando de Soto (1539—1543).

Only two writers are known to have composed books in the Timucua language; the priest Gregorio de Mouilla (of Mobile?) whose Doctrina Christiana is probably lost now, and the Franciscan Padre Francesco Pareja. Born at Auñon, in the Spanish diocese of Toledo, Pareja was with eleven other priests commissioned to Florida by the "Royal Council of the Indies," arrived there in 1594, converted many of the natives and founded the monastery (*custodia*) of Franciscans at St. Helena, 12 leagues North of San Augustine. In 1610 he removed to the city of Mexico, wrote a series of books, all of which were printed in Mexico, and died there January 25, 1628. Of his Grammar (Arte) and Dictionary (Bocabulario) of the Timucua and of some minor religious tracts in this language no copy is known to exist at present in any library, though some may turn up some time in Spain or in the Mexican States. I derived my information from two original Catechisms, bound in one volume, and from a Confessionario of Pareja, printed 1612 and 1613 in 16mo. and brought from Spain to New York by Mr. Buckingham Smith, once Secretary of the American Legation at the Court of Madrid. So careless and unreliable is the orthography of these texts and of the Spanish version standing opposite, that doubts arise whether Pareja himself, who, according to Hervas, lived at Mexico when

his writings were printed there, corrected and revised the proof sheets. The Spanish version is neither verbal nor faithful, often half, often twice as long as the Timucua text, and very frequently misleads the studious reader. Hence the utmost caution must be used in making researches on the idiom.

In spite of all these imperfections, Pareja's volumes are the most precious relics of Floridian antiquity. The texts often make two vocables out of one, or erroneously combine two distinct ones into one; but soon the student becomes accustomed to this caprice and enabled to righten the orthography himself. The books and titles are minutely described by Mr. B. Smith in New York Historical Magazine, 1858 and 1860, and on page 3, of the volume of 1858 he gives also some eighty Timucua words, mainly from the Confessionario, with their meanings. For the correctness of some of them I am unable to vouch. The *Tinqua* language mentioned by Ludewig (Literature of Am. L.), is a blunder, instead of the correct form *Timuqua*.

Phonetic Elements.

Timucua syllables are composed from single phonetic elements with remarkable simplicity. They either consist of a vowel only or more generally of a consonant followed by a vowel, and syllables terminating in an *s*, a nasal or other consonant are of rare occurrence (*hibuastu*, *mantu*). The language has a quite numerous and complete series of sounds, and since Pareja does not use any diacritical marks on his Spanish letters, we might infer that it had about as many sounds as the Spanish alphabet, omitting the *ll*, *x*, *z* and *j*. *D* and *g* are scarce and of diphthongs none existed, excepting perhaps *au*. The *h* probably remained silent in most words where we find it, and stands there only to indicate hiatus of two vowels: *lchaue* for *le-aue*, *bohono* for *bo-ono*, and was equally silent at the beginning of words: *habosota; hachibono* (frequently written *achibono*). There was only one palatal *ch* (our *tch*) standing either for *tch* or for the softer *dsh*. *Qu* or *q* is our *k*; the *gu* or English *w*, so frequently occurring in Indian languages transcribed by Spaniards, does not occur here. Unfortunately the "*Arte*" of Pareja, which alone could inform us of his mode of transliteration authentically, is lost, perhaps forever, but from what we have we may safely conclude that no clicks, very rough guttural sounds or jaw-breaking clusters of consonants entered into the structure of this remarkably sonorous idiom, which possessed the following twenty-one articulations:

Vowels: u, o, a, e, i.
Consonants: k, g, t, d, p, b, tch, f, h, y, s, v, m, n, r, l.

In vocalism the nearest approximation to Timucua is made by some Polynesian tongues, f. i., that of the Sandwich Islands, by the Matlaltzinca or Pirinda of Michoacan and by the Tonto, spoken on middle Gila River, Arizona. Perhaps one-third of all words begin with vowels. The most frequent initial consonants are k, n, m, p. R and some other consonants do not begin any words, and it is somewhat doubtful if this r is our rolling

r, for this sound is extremely rare in Indian languages.* Our *sh* and *th* are wanting, but the *f*, not frequent in America, occurs here and in the Chahta-Maskoki dialects, while Apalache shows no trace of it. (See specimen of this language in *Historical Magazine of New York*, 1860, page 40.) Very few instances occur, where a consonant is geminated (*alipassa*), but with vowels this is very common. The surd pronunciation of a vowel is not distinguished in the texts from the clear and nasal one, but it is natural to assume that some of the *e*'s were what the French call *e muets*. Nasalizing is sometimes indicated by a final *n*.

The interchangeability of a class of consonants observed through all America is found also in Timucua and it would be singular indeed if we did not discover it in this peninsular idiom. The cause of this phenomenon must be sought for rather in the capacities of the auditory organ than in the structure of the vocal tube, we think. The following alternative processes are observed :

b and *v*,	*mobicho, movicho ; balu, valu.*
b and *m*,	*hachibueno, hachimueno.*
h and *f*,	*inihi, inifi.*
l and *r*,	*oyoluno, oyorano ; tchiri, tchale.*
t and *d*,	*manta, manda.*

Alternating vowels :

ue and *o*	*hachibueno, hachibono.*

Pareja does not mark but exceptionally the emphasized syllable of a word, but we can safely assume that the accent rested on the radical syllable in words of three or less syllables, and that many particles were added *enclitically* to the words governing them. The elision of unaccented vowels occurs at times and then causes two consonants to follow each other.

Inflection.

Timucua incorporates particles of relation to a large extent and has also reached a considerably high degree of polysynthetism. The differentiation between verb and noun is not so thorough as in the Indo-European tongues, and we find that many particles of relation occur in both classes of words. These latter particles are *suffixed* to the radical syllable and prefixes are seldom found. Duplication of the root or of any other syllable is a rather uncommon means of grammatical synthesis, neither is it of frequent use in any of the eastern languages of North America.

The noun is inflected by means of postpositions and case-suffixes. The locative case is expressed by *-mi* : *pahami*, in the house, sometimes by *-la* : *acòtala*, in the bed, or by *-ma* : *macama*, in the sea. But this particle *-ma* is used to express the most diverse relations of the noun and also of the verb ; it does not only form plurals of substantives, but also possessive, dative, objective and other cases, and thus seems to be comparable in some respects

* Is it the sound *kh*, the Greek χ, which Spanish grammars of American languages render so often by R?

to the ubiquitous article-pronoun of the Cháhta language. Frequently other postpositions are placed between *-ma* and the word-stem, or after *-ma* as final syllables.

Other postpositions frequently occurring in the Timucua noun are : -co, -coco, -ke, -la, -le, -leta, -leke (-leqe), -ni, -no, -si, -so, -ta, -te, -ti, etc.

The demonstrative particle *na* is employed in many different ways. When placed before the noun, it serves as a definite article ; when suffixed to it is the possessive pronoun "*my, mine.*" Owing to the indistinct pronunciation of unaccented vowels, which we observe sometimes in Pareja's texts, *na* appears also under the shape of *ne, nu ; na* enters into the composition of the pronoun *ano,* "somebody, something, some one, one." *Ni* in *ni sikisama* means "*me ;*" these words signify *my father*, and a literal translation would render them by "the one, who procreated me." *Ki* is here the radical syllable In his Catechism, page 18, Pareja gives the series of ordinal numbers which unfortunately runs no further than to seven : *Na* is prefixed to each of them as the definite article, and the ending-*mima* is the possessive pronoun of the third person singular : *his, her, its.*

Cardinals :	*Ordinals :*
mine 1	minecotamano, kibema
yucha 2	na yuchamima
hapu 3	na hapumima
cheketa 4	na cheketamima
marua 5	na maruamima
mareka 6	na marekamima
pikicha 7	na pikichamima
piqinahu 8	na piqinahumima
peqecheqeta 9	na peqecheqetamima
tuma 10	na tumamima
yahagala 11	
iuchaagala 12	
hapuangala 13	
chequetangala 14	
ero tuma yucho 21	
tuma hapu 30	
tumacheqetama 40	
itumacheqetoqe marua 45	
ero chupiaco iuchaagala 12,000	

In this series many terms are ending in *-a* ; four is formed from two, *cha*, *che* appearing in both, and *ke* in "four" being an additive particle "together." We cannot decide as yet if the series is based on the quinary or simply on the decimal system of counting.

We often find appended to nouns, especially to substantives borrowed from the Spanish, the suffix *-mueno, -mano. Mueno* means "the name," or "to name, to call" and composes terms like *muenolete* is called, *hachibuena, hachimueno* "which thing? which? what?" (literally : which

name?) In the Spanish word *fémono* it means the *so called* faith, in *gatomano* the *so called* cat.

The termination *-male* serves to designate two members of a family equidistant in their relationship or consanguinity, f. i., father and son, grand grand-father and grand-grand-child etc. The former two are called *iti male*, the latter *maulmale*; but if the grand-grand son is mentioned before the grand-grand-father, another term, *kisitomale*, will be employed. Uncle and nephew is *itelemale*, nephew and uncle, however, are called *kiemale*. It will be difficult to find any other language on the face of the globe, even in America, where the degrees of relationship are distinguished with such extreme accuracy.

In a community with so aristocratic forms as that of the Timucua we must expect to meet with a number of *reverential* endings appended to nouns and verbs, which were used in addressing persons who commanded respect through their position: kings, chiefs, governors, parents, friends, matrons, etc. They are extremely frequent in the idioms of the Mexican States.

A demonstrative pronoun *caki* occurs in very different forms (*ca*, *caqe*, *caqui*, etc.), and answers to our *that* and to the personal pronoun *he*, *she*, *it*. Connected with the prefix *o* it occurs as *oque*, *oqe*, and its plural forms are *care*, *carema*, *oquere*, *oquare*. Etymologically connected with it is the demonstrative particle *-co*, frequently redoubled to *coco* and appended to substantives and adjectives. *Acu*, *ico* means every one, all; *ano paracusi olata ico*, lit. "one king of all chiefs," was the official title of the Timucua monarch or head-centre.

When standing at the end of the sentence, as in questions, "*thou*" is expressed by *cho*, otherwise by *chi*, and in locutions like *chi isucu?* are you a herb-doctor? it replaces at the same time our substantive verb *to be*, of which all American languages are deficient. *Itimi isomikene chi nahe?* Have you father and mother? *Anoco orobusobi cho?* Did you bewitch anybody? The former sentence shows the use of the postposition *ke*, which in fact answers to our "and," but really signifies "together, along with," thus fulfilling the function of one of our prepositions.

The interrogative pronoun or particle who? what? which? *cha? acha? hacha?* appears chiefly in compounds, formed with different parts of speech. Most frequently the particle *ke* just spoken of is connected with it.

hacha chi mueno? which is thy name?
chanco (contracted from chanaco)? whence? wherefrom?
hachamueno (see *supra*).
hachakene? which? and which? and what?
hachakenenco, hachakenike? and why?
hachakenta, hachakentana? how? how then? and how? in which manner?

Verbs are derived in various ways from substantives, adjectives, or from other verbs. Some of the principal derivational endings, particles or forms are as follows:

-lehaue forms causative verbs: *ituhu* to pray over, enchant, bewitch: *ituhu-lehaue mobi cho?* Did you order (the sorcerer) to pray over (something)?

-letahaue involves the idea of duty, or obligation: *bohono-letahaue* must be believed; *yaleno-letahaue* must be observed.

-so, -sota, -sote intensify the meaning of the transitive verbal base to which they are appended and also form causative verbs: ituhusobi cho? did you really bewitch?

-manta means to desire, wish for; incorporated into verbs it forms *desiderativa*.

Full paradigms of the verb cannot be given yet, but such elements of verbal conjugation which seem to be recurring in most verbs, are, when applied to the verb *mo*, to speak:

ni mola I speak.
chi mo thou speakest.
oque mo he, she speaks.
ocare moke they speak.
chi mobi thou didst speak.
momate speaking.

The particle or sign of the preterit is -bi-, -vi-.

Some personal pronouns used here are similar in form to the possessives, which are not prefixed, but constantly suffixed to nouns:

itina my father.
itaye thy father.
itimima his, her father.
itinica our father.
itayake your father.
itimitilama their father.

To this table must be added a variety of inclusive, exclusive and dual forms for the first person of the plural:

our father: itinicale, itinicano, itimile, heca itimile, heca itinica.

Adjectives, when used in an attributive and not in a predicative sense, are placed after the substantive which they qualify. The direct and the indirect object of the verb is very frequently placed at the head of the sentence.

Selected Texts.

To enable students of American languages to judge for themselves of the nature of Timucua, I insert a series of texts which I have taken from the most interesting parts, linguistically and ethnologically considered, of those writings of Pareja which I have had the good fortune to consult. To one series of questions I add the Spanish version of the original, to the others the English translation of the Spanish version.

For the old-fashioned, initial *y* of the Spanish and Timucua text I have substituted the *i*, to which it is equivalent.

Terms of kinship and genealogies.

Pareja gives several series of terms used in his time for *the pedigrees and castes* of the nobility and the people, which evidently are of totemic origin:

of terms for the degrees of *relationship* by consanguinity and by marriage, some of them used by men, others by women only, or by both sexes indiscriminately. The following is the most interesting of these pieces from a purely *linguistic* standpoint and I give it in the original Spanish. These terms were used by *both* sexes, as Pareja remarks.

(*From the first Catechism; pages not numbered.*)

Los que son naturales, ó de una tierra, *Uti nocoromale.* Los que son de un pueblo *Hica nocoromale.* Los que son de una casa *Paha nocoronomale.* Somos de un pueblo *Hica niahobale*, ó: Somos de una casa todos *Hica nie orobale, paha niocoralebale.* Somos de un linaje, ó casta, ó generacion *Anoquela niyahobale.* Sois de un linaje, ó generacion, ó estirpe *Anoquela chiyahobale.* Son de un linaje, ó casta, ó generacion *Anoquela yahomale.* De que linaje eres? *Anoquela chichaque ne?* Quienes son tus parientes, ó parientas? *ano chichaque ne chitaco chiano mi?* ó: *chitaco anoya?* Parientes y parientas, y hermanos y hermanas se dizen entre si: *Ano cirona*, ó: *elapachana.* Hermanos, hermanas, parientes y parientas se dizen *Anoniamale*, ó: *elapachamale*: *Elapacha* es: comun parentesco: y estos tambien son comunes: *Anomeiema*, ó: *ano oquomi*, ó: *ano oquo malema.* Viudo, viuda: *abua*, llamado por *sus* parientes ó parientas solamente.

Todos los que descienden de los linajes que se tienen por parientes se llaman todos estos descendientes, *ocorotasiqino.* Pero todos los que descienden de un linaje, y parentela, se llaman *siqita pahana.* Y esta descendencia ha de ser por linea de varon; por que si es por linea de muger, se llaman *anoquelama* ó *Anona;* parentesco de lejos *neucanimi.* Amo, señor y basallo, esclavo; y amo y esclava; y amo y criado y criada: *Anocomalema*, Amo y criado, y amo y basallo: *Anoquelamalema* ó: *anopequatamale.* Señor y esclavo; y esclava y esclavo; y esclava y señor: *Atemalema.* De modo que si se pone primero el amo diremos: amo y criado, y si se pone el criado antes quera dezir criado y amo, y assi de todos los demas que quedan dichos, y se hallaren de estos generos.

On the nativity of Christ.

Doctr. Christ. p. 24.

Para que mas se hizo hombre?	Acuyano hachaquenenco bueta caqua taanolebi?
Para que mas se hizo hombre?	Acuyano hachaquene caqua taanolebi?
Pues para que se hizo Dios hombre?	Hachaquenique Diosimano caque taanolebi?
Como puede nacer de Madre Virgen?	Isomima aquitasique lenima hachaquentana aruquilehe?
Sobrenatural y milagrosamente.	Inino lebima tana inibitileta hiquo timonococoleta hachiti moponta siqitantela ha.
Y su Madre, Sancta Maria, vivió	Mine isomimano, Santa Maria mu-

despues siempre Virgen?

enoma, etabualunimate nanemi aquisatique cumenu yaqualebi?

Si, perpetuamente fue Virgen.

O, nanemi aquita cumenu yaqua hibuabila.

The following interrogatories mainly refer to the SUPERSTITIONS, *vices* and *heathen practices* of the natives, whom the Spanish priests had come to reform and civilize: they are of uncommon interest to the investigator of American ethnology.

Questions addressed to Chiefs and Governors.

(Confessionario, pages 127, 128, 129.)

When intending to join a hunting party, did you order prayers to be said over the tobacco beforehand?

Emiso haueleta hinino ituhusobi cho?

On arriving on the mountain, did you order to lay the arrows together and let the conjuror say prayers over them for your benefit?

Hurima minonomano atuluma horocoqe naribama ituhuaue mobi cho?

Did you say that the first deer killed should belong to the conjuror?

Honoso nihe qibema itufama honomi-lehauele mobi cho?

Did you order that over the lake prayers should be recited before fishing in it?

Camapatama hibinoma ituhu chicaqe quelano-lehaue mobi cho?

In the same manner, did you order that of the fish caught for the purpose of eating, the conjuror should get one-half, after having prayed over them?

Acuqueleta hiquinomano ituhusota cuyumono itufama isaqita ohonolehaue mobi cho?

The first fish caught did you order prayers to be said over it and then to throw it into the provision-house (barbacoa)?

Cuyupona qibema inti uquata ituhuta oquono-lehauele mobi cho?

Did you before tilling the field recite the ancient ceremony to the conjuror?

Pile pulunu-lehauema ituhusuta hibuata bechata pulubi cho?

Did you [think it sinful not to] pray over the first maize of the crop?

Tapolabaca qibema ituhusuta hebi cho?

The first time when the corn-crib was opened, did you make any flour for food? and after pounding flour did you pray over it?

Abopaha falino qibema ipita huyosota ituhutaqere hebi cho?

In gathering chestnuts and palmetto berries, did you perform with the laurel and while praying, the ceremony which had come out of use (que solia deshazer)?

Afatacó si apuco quenema hebeta nali qui iribosota ituhusobi cho?

Did you say: "I shall not eat any mountain fruit, unless prayer be offered over it"?

Aya honoma ituhumuleqe hehanimanda hanibi cho?

Did you wish to eat any other fruit, over which prayers had been offered first?

Calamaqibe ituhumuleqe hehani manibi cho?

From these curious questions directed to the principal men of the tribe, it appears that one of the duties incumbent to a chief was the superintending of the ceremonies of incantation through the conjuror or prophet. Evidently these prayers and ceremonies were intended to consecrate natural objects, which formerly had been profane, for men's use, and at the same time to propitiate the Divinity in favor of those using them.

Questions directed to Rural Laborers.

(Confessionario, page 129 recto).

Did you not eat the first maize of the crop?

Hulubota qibinoma inti uquabi cho?

Did you not eat the maize of the newly broken field (de la roça nueva)?

Abara elema ecano qibema inti uquabi cho?

When the owl was crying did you believe that it would have mercy on you?

Hitiqirima hebuataqe hoba nimelabonihaue mota bohota mosobi cho?

When the woodpeckers sang, did you say you would not utter any cry, because it would cause you to bleed from the nose?

Tiniboma hebuataqe iquasetiquanichinima isitocobile bohota mocobi cho?

When the owl or red owl was crying, did you say: "Do not interrupt it, for it would cause you mischief?"

Atofa hororoquene hebataqe nanibeti, queni intila mobi cho?

In winter time did you [think it sinful to] eat the small partridge (la gallina pequeña)?

Caya-ule-i chira na minama inti uquabicho? (words in [ ] not in Timucua text).

Questions to Hunters.

(Confessionario, page 129).

When a [young] deer was bleating, did you say: "If I do not take any herbs into my nostrils they will be shaken up," and if in this thought you have sneezed and returned home, did you bathe in the juice of the herb? and have you believed that when omitting this you would certainly die?

Honoso hebasi, habeleta itorita chininipe lotahaue manda, niyefela tasamota niyena haquista, paha ponomate samota quosobi cho? nocomi nini habela manda bohobi cho?

Did you say or perform any ceremonies for the chase by kicking with the feet (armando la coz), and did you stop eating of the game which you had killed, believing that you would then kill no further game?

Uquestanaye, hachicaresta isota mosobi cho, honoso ilifotanaye, intiquata hehanano ni ilifohaueti manta bohota mosobi cho?

Did you forbid that the liver and lungs of the game should be thrown in cold water to cook them, because you could then shoot no further game?

Chofama pilenoma ibine ichicosa ecatiquani ilifoqi tinibalusihabele mota mosobi cho?

Having pierced the game with arrows without killing it, did you order prayers to be said over an arrow, believing that with the next shot the game would die?

Baliteque atulu nalifochiqe, nihetileqe, atuluma ituhusota niyena mocosota, naipolotecata mosobi cho?

The sauce (caldo) of the game or of the partridge, did you prevent its spilling because the lasso would not catch then any more of them?

Neha ichuquininoleqe honosomate, cayamate quenequa uquesinoma uba hauetila manda bohobi cho?

(Skipping a few questions on page 130 r. and verso on account of their great length, I continue with page 131 recto).

Did you forbid going up to the corn-crib, unless prayers had been offered for it to the Spirit?

Anomisonoma ituhutetima abopahama iquinole-hamonta inti uquata bohota mobi cho?

For seeking the turtle and catching it did you pray?

Caramaba pilisota hiti hebuanoma ituhuta quosobi cho?

In passing with the canoe a rock ledge (barra ó vaya) and there being a surging of the sea, did you whistle at it for not getting upset?

Ibi abagalata nayeno ticoma piluabe tileqe ibinaqe elota piluhauetila manda bohota elofibi cho?

Did you whistle (or hiss) to the storm, thinking that it would cease then?

Aqetuqe elotequahaniso hale manda bohota elosibi cho?

When you find yourself in similar distress, call the holy Name of Jesus, and Jesus will help you.

Naquentaqe entahanaye Jesus motabisato tachiqe chi ibalu hauele chilarahaue quenela.

Superstitions concerning warfare.

(Confessionario, page 131 r. and v.)

When it was lightening did you forecast war?

Milicotaqe iri nabolotele manda bohota mosobi cho?

When going to war did you bathe yourself in the juice of certain herbs?

Irimi haueleta atulu ni iubue hau ele niye suquoniqi mobi cho?

[Know well, my son,] that although you bathe in or rub yourself

Naquostaniye, samota monocotacu Diosima manininco nacu atulu

with this weed, the arrow will nevertheless transfix you if God does not guard you.

chi iubehe yanacu maha suquonina ticotacu Diosi manineco nacu atulu chi yubeheti quenela.

Questions addressed to women.

(Confessionario, page 132 v. 133 r.)

Did you eat any fish or deer-meat during the catamenia?

Ibirita cuyumate honoso henomate quene inti uquabi cho?

A short time after confinement did you eat fish or such things?

Eta baluta cuyuleqe hachibueno eyoleqe quenema inti uquabi cho?

Shortly after the confinement did you make a new fire (candela)? Did you make any during the catamenia?

Eta baluta taca chale quosobi cho? Ibirita taca chale cosobi cho?

Anointing your own hair with bears' grease (azeye de oso) did you think it sinful to eat fish for so and so many moons?

Ara uque naponaye cuyuhanta acuhiba meteta minoqe henolebinco, hehanimota mosobi cho?

Did you eat any coal, dirt, or broken pottery, or fleas or lice?

Tacachuleheco, qisaleheco, ulipassaleheco quenehata, ibiqitaleheco, hibeleco quenema iparubi cho?

[Do not eat coal nor dirt nor fragments of pottery, for] they make the person sick, and it is sinful on account of the injury produced.

Nacare henomano inti lehe caqua atenaso, ninoleqe, ano iqilabosobiqe hecaqua atenasoninoma intele hani hache.

After your husband had left you, did you bathe in the juice of herbs, thinking that he would then return to you?

Inifaye chi haniqe viromaqua niponosihero manda, niye nisamosono-lehaue mota bohobi cho?

Did you say: tinge ye my palm-leaf hat with a certain herb (saumad me el guano con cierta yerba) and he will not desert me?

Canima niye ni naquila sinoleqe utihanle mota bohobi cho?

And having tinged it, did you put on your petticoat?

Cani meleninoma niye naquilanolequemeleniqi mobi cho?

Did you think that in tinging your hat in that intention somebody would get enamored of you (se aficionará)?

Cani abinoma niye namocosonoleqe abiqiti anoco ni homanisihaue manda bohota quosobi cho?

Did you fast in this intention?

Na quostanayeno itoribi cho?

And thus you arrived with somebody almost at night time and you performed the ceremony as if for eating and drinking?

Itoritequa ilaqiqe henomate pele ta, ibinemate peleta quosobi cho?

I do not pretend to have written all the words of these sentences and of the vocabulary, following hereafter, in a strictly correct manner, but cer-

tainly more correctly than they are found in the original. A good orthography cannot be established before the idiom is thoroughly understood.

In studying and analyzing the words of Timucua, the same idea obtruded itself to me, which occurs so often to students of the South African and of some Western American languages: "*Are not all the words, even their radical syllables, built up of pronominal roots?*"

Words and Sentences.

I have placed here in alphabetical order some of the vocables, the meaning of which I have ascertained through careful comparisons of the passages in which they occur. Some of the words which I have mentioned in the grammatical notices, the numerals, f. i., I have omitted in this table.

abo maize, corn-plant.
abopaha corn-crib, Span. garita.
aboto stick, staff; to beat with a stick: anoco abotobi cho? did you beat somebody?
acu all, every; acu caki all this, acu kelata in the same manner, exactly so.
afata chestnut; afataco hebeta for gathering chestnuts.
aha acorn.
apu grape of palmetto, palmetto-berries.
aquita maid, aquitasiqe virgin, damsel.
ara bear; ara-hasomi those forming the Bear-Pedigree.
aruqui child, descendant.
cuyu-hasomi aroki descendants of the Fish-Pedigree or family of fish; aruqui-lehe he was born.
atofa owl.
atulu arrow.
balu, valu life; balu nenemi eternal life.
eta baluta after a (recent) confinement.
bohono to believe.
caya chicken, partridge, turkey.
camapata to fish; c. ibinoma to fish in the lake or lagoon.
coro the same; uti nocoromale those belonging to the same country.
cuyu fish.
chebe to lose; hachibueno chebeque, h. chebuamano something lost.
chini nose, nostrils.
chiri small, young. chirico viro boy, son (lit. little man, young man) chirico nia daughter, both used only by their parents; chirima, amita chirico my youngest daughter. Related to *chale* new.
chofa liver.
chuca? how many times? (from cha, hacha? who? what? which?)
eke, equela day.
hasomi lineage, pedigree.
caya-hasomi chicken-pedigree.
ara-hasomi Bears' lineage.

hebua, hebuata word, saying; to speak, to emit voice,—hebuataque tiniboma the woodpeckers sing (see: honoso).
nurabuote a lie.
heno to eat; henomate ibinemate for eating and for drinking, chucaya haheno? how often did you eat? hehani manibi cho? did you wish to eat?
hibe louse.
hica settlement, town, village; appears in Tarahica and some other local names mentioned above.
hica nocoromale the citizens of the same town.
hiyaraba American lion.
holaba (also: tapolaba) maize, Indian corn; holabaca qibema ituhubi cho? did you pray over the first-grown maize?
holata chief, holata aco, olata ico: all chiefs.
honoso deer, antelope; honoso hebasi when the deer is bleating.
huta to cohabit; niaco hutabi cho? did you cohabit with a woman?
ibine water; pond, lake, sheet of water.
hibita river.
ibinese to bathe.
inibiti (see below).
hibua to rain. hibuabi cho? have you produced rain? did you cause it to rain?
banino rainbow.
ibirita to menstruate.
mucu-bine tears (lit. eye-water).
icasini to altercate, quarrel; anoco icasinibi cho? did you quarrel with some one?
ikeni to kill (probably a contraction from: ike nihi, to make die); anoco ikenibi cho? have you killed anybody?
inibitisote to drink to excess, to fill oneself with liquor; see ibine.
inihi consort, husband *or* wife. inihimale married couple.
iri war, warfare, irimi haueleta for going to war; iri-hibano war-councillor; this caste were descendants of the Fish-family.
urri-paracusi war-prince.
isa mother.
isu, isota herb, weed; a plant, the juice of which was used for superstitious purposes. Nie chaqueneco isota with which herb?
isucu, herb-doctor.
isucu echa crazed, possessed by a demon.
iti father; itimileno "our father": spiritual father, monk, priest.
itori late, posterior.
itorimitono the last order of the second pedigree of Timucua nobility.
itori to fast; equelaco maha itorinoma the days of fasting.
ituhu to pray, conjure, invoke, charm, bewitch; ituhusobi cho? did you conjure or bewitch? did you say prayers over something?
itufa sorcerer, wizard, medicine-man.

ya, aya not, no; in *yalacota* misuse, abuse it has the meaning of our prefix: *mis-*

kala fruit; calama kibe the first fruits.

kenele afterwards, subsequently, then.

kibe first; adv. firstly, at first.

tapolabaca qibema the first maize of the crop; hulubuta qibinoma the first maize. qibe ituhumuleqe over which a prayer has first been recited.

kie child (used by men); kiena moso my first son, my first daughter. kiani cocoma my children of later birth. kimale son *and* father.

kisa earth, ground, dirt. qisa iparabui cho? did you eat dirt?

koso to make, produce; taca chale cosobi cho? did you make a new coal-fire?

lapuste, lapueste to require, ask for.

mani to agree, consent; anoco nihihero manibi cho? have you wished somebody's death?

manta to desire, wish; ni mantela I wish, chi mante you wish.

mine prior, preceding, first; large, great. miso anteceding, older, previous; ulena miso my child of first birth, eldest child (used by females only).

mo to say, speak; to order, command. movi cho? mobi cho? hast thou ordered, or said? mote cho? do you consent? do you say so? o, motala! yes, I say so!

mueno, mono name, to name.

muenolete Diosima? is he called God?

hachimueno, hachabueno which thing? thing, object.

visamano name.

na kostanaye? in which manner? through which process? na quostanayeno by what intention?

nayo white; honoso nayo white deer.

nanemi perpetual, eternal; adv. always; balunu nanemi nohohauela to give me eternal life.

nasi son-in-law.

nariba old (of persons). naribama ituhuaue mobi cho? did you order the old sorcerer to say his prayers?

nia woman, female (see pacano).

nihi to die, expire; honoso nihe qibema the first deer killed.

nocomi true; nocomicoco manda with true desire; Dios nocomi bohonoacoma to believe truly in God.

nulasi to tickle.

o yes, yea, certainly.

obacha to kiss.

orobo to advise? orobinibi cho? did you confess (in Church)? anoco orobasobi cho? did you bewitch some one? na orobisionoma advices, counsels.

pacano subsequent, second to.

nia pacano a spinster; pacanoka my second child (hijo, hija de en medio). viro pacano unmarried man.
pequata vassal.
pona to come; ni ponala I come.
ponachica? do you bring? (see: viro).
soba meat; deer-meat.
taca fire; coal-fire; taca chale new coal-fire (candela nueva in Span.): taca chu carbon, charcoal.
tafi sister-in-law (used by men only); tafimitana, ni tafimitama the brother of my husband (used by women).
tico canoe, boat; ticopaha ship.
tinibo woodpecker.
ulipassa fragments of pottery (uli = Span. olla).
uti earth, land, country; uti-hasomi those forming the Earth-pedigree or Earth-Family, utina my country; uti nocoromale the inhabitants of ONE country.
viro man; chiri viro boy, son; viroleqe uquata puenonicala, I brought here a male child.

The Approaches to a Theory of the Cause of Magnetic Declination.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, April* 6, 1877.)

So many questions of historical, economical and scientific interest are bound up with the variation of the magnetic needle from the astronomical North, and the change in the rate and sign of this variation, that the following remarks may be excused, even if they only succeed in impressing upon the imagination the immense amount of work which yet remains to be done. The best compendium of the history of the subject is contained in a prize essay on Terrestrial and Cosmical Magnetism by E. Walker, Cambridge (Eng.), 1866, while for particular discussions of special groups of observations, Sabine's Secular Variations of the Magnetic Needle, in the Trans. of the Royal Society during the last five years; Prof. A. D. Bache's discussion of the magnetic elements, observed at Girard College during the years 1840–45 inclusive; in Coast Survey Reports for for 1855, 1858, 1859, 1860 and 1862, and especially Mr. C. A. Schott's labors on these and all other obtainable data in the United States, have been mainly drawn upon. Besides these, for general questions relating to the subject, Barlow's treatise in the Encyclopædia Metropolitana; Airy's treatise on Magnetism, London, 1870; Numerical Relations of Gravity and Magnetism, by P. E. Chase, Trans. A. P. S. 1864; Prof. Loomis' collection of magnetic observations; Silliman's Journal, 1838 to 1840; Reclus, Despretz, Becquerel, Humboldt, "Magnetism," by Sir W.

S. Harris and H. M. Noad, and "Diurnal Variations of Declination," by Wm. Norton, have been consulted.

A large number of observations with their authorities will be found at the end of the Report of C. A. Schott in C. S. Report for 1858.

Resumé from Coast Survey Reports.

In the C. S. Report for 1855, p. 302, is a chapter by Prof. A. D. Bache, on the Magnetic Declination in the northern part of the Gulf of Mexico. The observed declinations are reduced to the common date of Jan. 1850, by an assumed annual decrease of 0′.5 E. declination from observations made at Pascagoula in 1847 and 1855.

The equation representing the true declination with reference to the latitude L and the longitude M of any place, here follows :

$dV = v + x\,dL + y\,dM + z\,dL\,dM + p\,dL^2 + q\,dM^2$

dV = difference between the observed decl. and the assumed decl. V′

V = correction to the assumed V′.

The solution of the conditional equation, for any latitude L and longitude M gives the following expression for V :

$dL = L - 28^\circ.04.\quad dM = M - 88^\circ.69.$

$V = 7^\circ.39$ East$-0.025\ dL + 0.296\ dM + 0.0188\ dL\ dM - 0.0094\ dL^2 - 0.0076\ d\,M^2.$

All the declinations being East are treated as essentially positive quantities.

The number of groups of stations selected was six, in order to solve the six unknown quantities in the first equation.

There were the following number of stations in each group. The Roman numeral indicates the number of the group, and the Arabic numeral the number of stations : I, 1 ; II, 1 ; III, 4 ; IV, 4 ; V, 3 ; VI, 1.

The average of the residual—(*i. e.* the difference between the observed and computed declinations)—was $0^\circ\ 056 = 3'.3$.

For the observations in the general table, the form of the conditional equation is the same as above.

$$V = V' + v + x\,X + y\,Y + z\,X\,Y + p\,X^2 + q\,Y^2.$$

The annual variations were an estimated approximation by mutual comparison of the known values at Toronto and on the Atlantic coast.

The origin of co-ordinates is assumed midway between lat. 43° 26′, long. 70° 24′; and lat. 29° 07′, long. 83° 03′; the co-ordinates of position are expressed in degrees and decimals and *were graphically obtained* by careful plotting on a large scale.

Mr. Chas. A. Schott in the same volume furnishes a discussion of the magnetic declination on the Atlantic and part of the Gulf coast (communication to the American Association for the Advancement of Science, Appendix 48 to Coast Survey Report for 1855,) of which the following are some of the points :

Hausteen's publication "Investigations of the secular variation since the magnetic observations in Coast Survey Report of 1854," gave a new impulse to these investigations.

Dr. Bowditch and Prof. Loomis were mainly instrumental in bringing this subject prominently to the notice of scientific men.

Prof. Loomis gives (Silliman's Journ. of Sci. and Arts 1840) the annual change of variation in 1840 as 2′ *for the Southern States*, 4′ *for the Middle and* 6′ *for the New England States.*

The essay is divided into: (a) Stations of reliable observations prior to 1740; (b) Ditto after that time; (c) Results from comparatively recent observations; (d) Establishment of formulæ expressing the secular variation within the limits indicated on the title page (*i. e.* the Atlantic and part of the Gulf coast).

Under (a), Providence, R. I., Hatboro', and Philadelphia, Penna., are selected. Thirty declinations collected by Mr. M. B. Lockwood from actual observations and recorded bearings of a number of objects, are considered. The formula employed is

$$D = d_0 + y\,(t - t_0) + z\,(t - t_0)^2 + u\,(t - t_0)^3 + \&c.$$

Where y, z, u are unknown coefficients, and $D = d$ where $t = t_0$. Putting $d_0 = d_1 + x$ where x is a small correction to the assumed value of d, and omitting higher powers of the time, than the third

$$D = d_1 + x + y\,(t - t_0) + z\,(t - t_0)^2 + u\,(t - t_0)^3.$$

Assuming for t_0 the commencement of any year and for d_1 the supposed corresponding declination (expressed in degrees and decimals) then each observed value for D at the time t furnishes the following conditional equation: $0 = d_1 - D + x + y\,(t - t_0) + z\,(t - t_0)^2 + u\,(t - t_0)^3$.

From this by the application of least squares the normal equations and coefficients of x, y, z, u, are obtained.

"The above formula is capable of giving two maxima and two minima, whereas the omission of the third power would give but a minimum. *And this as we know from observation took place about the commencement of this century.* t_0 is assumed as 1830;* and $d_1 = + 7.20$."

A table of thirty observations in Providence, R. I., is reduced in size by substituting a table of sixteen means, which here follow:

1717	D = + 9.60	1790	D = + 6°.18
1720	9.47	1800	6 .25
1730	8.92	1810	6 .40
1740	8.28	1820	6 .66
1750	7.67	1830	7 .19
1760	6.99	1840	8 .42
1770	6.49	1842	8 .65
1780	6.27	1844–8	9 .25

Substituting in the above equations we have:

$$0 = - 2.40 + x - 113\,y + 12769\,z - 1442897\,u,$$

and similarly for the other fifteen equations.

Multiplying each of the sixteen equations by the coefficient of the first unknown quantity and adding them all up, we get the first of the normal equations, and the same operation performed for each unknown quantity will give the other normal equations.

* In the discussion of subsequent years this date was changed to 1850.

These would be as follows :

$$0 = -\ 7.49 + 16\,x - 736.2\,y + 63832\,z - 5792927\,u$$
$$0 = +\ 573.26 - 736.2\,x + 63832\,y + 5792927\,z - 562891700\,u$$
$$0 = -\ 79077 + 63832\,x - 5792927\,y + 562891700\,z - 56610893300\,u$$
$$0 = +8782402 - 5792927\,x - 562891700\,y - 56610893300\,z + 5831932000000\,u$$

To facilitate reduction Mr. Schott assumes $x = X$, $y = Y : 10^2$, $z = Z : 10^4$, $u = U : 10^6$. Dividing the first equation by 10^0, the second by 10^2, the third by 10^4, and the fourth by 10^6, he obtains the modified normal equations.

$$0 = -\ 7.4900 + 16.0000\,X - 7.3620\,Y + 6.3832\,Z - 5.7929\,U$$
$$0 = +\ 5.7326 - 7.3620\,X + 6.3832\,Y - 5.7929\,Z + 5.6289\,U$$
$$0 = -\ 7.9077 + 6.3832\,X - 5.7929\,Y + 5.6289\,Z - 5.6611\,U$$
$$0 = +\ 8.7824 - 5.7929\,X + 5.6289\,Y - 5.6611\,Z - 5.8319\,U$$

Their solution gives

$X = +\ 0.239$	hence	$x = +\ 0.239$
$Y = +\ 8.543$		$y = +\ 0.08543$
$Z = +\ 15.055$		$z = +\ 0.0015055$
$U = +\ 5.100$		$u = +\ 0.000005100$

and the formula for the declination becomes

$$D = +\ 7^0.439 + 0.08543\ (t - 1830) + 0.0015055\ (t - 1830)^2 + 0.000005100\ (t - 1830)^3.$$

A Table of Comparisons of the Observed and Computed Declinations at Providence here follows :

Date.	Observed.	Computed.	$\triangle$	$\triangle^2$
	○	○	○	
1717.....	+9.60	+9.64	+0.04	0.0016
1720.....	9.47	9.46	—0.01	0.0001
1730*.....	8.92	8.85	—0.07	0.0049
1740.....	8.28	8.22	—0.05	0.0025
1750.....	7.67	7.62	+0.05	0.0025
1760.....	6.99	7.08	+0.09	0.0081
1770.....	6.49	6.63	+0.14	0.0196
1780.....	6.27	6.29	+0.02	0.0004
1790.....	6.18	6.10	—0.08	0.0064
1800.....	6.25	6.09	—0.16	0.0256
1810.....	6.40	6.29	—0.11	0.0121
1820.....	6.66	6.73	+0.07	0.0049
1830.....	7.19	7.44	+0.25	0.0625
1840.....	8.42	8.45	+0.03	0.0009
1842.....	8.65	8.69	+0.04	0.0016
1844–8.....	9.25	9.05	—0.20	0.0400

$$\varepsilon_0 = 0.674\sqrt{\frac{\Sigma\,\triangle^2}{n-4}} = \pm\ 0^\circ.085 = \pm\ 5'.1$$

Mr. Schott proceeds to the establishment of formulæ expressing the sec

* A misprint makes this 1720 in Appendix No. 48, Coast Survey Report for 1855

ular variation in the rate of magnetic declination at any place within the limits of the stations named in the discussion.

By the tables thus framed the average error in the computed declinations is ± 0.0063.

He adds that the small table extracted from the Phil. Trans. Royal Soc. Vol. XI, abridged, from 1755 to 1763, which Hausteen used in the construction of the isogonic curves in his Erdmagnetismus, and which here follow are erroneous, inasmuch as we know that the Western declination had been decreasing from 1700 to about 1797, while the last two lines of this table make it seem to increase. It may be remarked that the first two lines virtually show increase of Westerly, because they show decrease of Easterly declination.

Observations by P. F. Jr.	Lat.	Long.	Declinations in 1700.	1730.	1744.	1756.
30 miles E. of Rodriguez Key, Fla.	25°	80°	4¾ E.	——	3½ E.	3 E.
76 miles E. 8° N. of St. Augustine, Fla.	30°	80°	2½ E.	——	¾ E.	0
32 miles E. S. E. of Cape Hatteras	35°	75°	2¼ W.	——	6½ W.	7 W.
365 miles E. of Sandy Hook.	40°	70°	7 W.	9 W.	11½ W.	12¾ W.

Mr. Schott's contribution to our knowledge concludes with the following remark:

"Before closing the appendix it will be seen that a look out for a time of inflexion to be expected about 1867 ± 15 years was not premature and indeed we find from the following comparison of the computed, and my last observed declinations that the latter always fall short of the former—a plain indication that the curve commenced turning its concave side towards the axis of abscissæ; or in other words that in 1855.5 the maximum annual increase had already been passed."

The annual variation of 1850 is recommended as a constant for some years till a new series clears up the point. He adds: * "Thus for example the declination in Boston in 1870 will be found by computing the increase for twenty years (the difference of 1870 and 1850) prior to 1850, and adding the same to the declination for 1880; the declination at Boston for 1870 becomes + 9°.81 + 1°.48 = 11° 18′ W." †

Referring to Mr Schott's admirable *winnowed tables* to accompany the C. S. Report for 1874 we find the Declination at Boston for 1870 given at 10°.90 (see table of decennial values). This varies from his prophecy by 0°.28 or 16′.8 (or with the correction suggested below by 0°.39 or 23′.4).

* Written in 1855.

† Should this not be 11°.29?

He concludes by calling attention to the following epochs.

	Differences.
Deduced maximum declination in 1679 ± 10 years.....	62 years.
Known first point of inflexion 1741 ± 10 years	57 years.
Known minimum declination 1798 ± 2 years	52 years.
Supposed second point of inflexion 1850.	

"From which it appears that the periods are diminishing or the velocity of the secular variation is increasing, which latter is sustained by a comparison of $V_{1741} = -4'.6$ with $V_{1850} = +6'.8$ or $+5'.9$," &c.

In Coast Survey Report for 1858 p. 192 to 197 Mr. Schott resumes the discussion of the subject. He announces the discovery at Hatboro, Pa. of a longer period of 234 years and a shorter one of 88 years, the range of the secondary motion being about $\frac{1}{15}$ of that of the primary or about $0^\circ.25$. The length of the shorter period as well as its epoch and range is different in different localities, but the fact of the existence of two such periods was afterwards confirmed by discussions of the periods at Burlington Vt. and Providence, R. I.

For the representation of the Hatboro observations the form was employed: $D = d + r \cos.(an + c) + r_1 \cos.(a, n + c_1)$ when n = number of years $\left.\begin{matrix} + \text{ after} \\ - \text{ before} \end{matrix}\right\}$ an assumed epoch; in this case the year 1830.

In the numerical application, the last term being neglected, the form adopted for the conditional equations was:

$0 = -D + d_1 + x + \cos. a\, n\, r \cos. c - \sin. a\, n\, r. \sin. c.$

The first assumption for d_1 was $= 5.2$ and $a = \frac{360}{250} = 1.44$ as pointed out in discussion of 1855.

In a second and third assumption (a) was varied. Afterwards that value was assumed which made the sum of the squares of existing differences a minimum. The probable ε_0 was $\pm 8'.6$ as against $\pm 11'.0$ in the former discussion.

The condition of the minimum declination is expressed by the formula $0 = 5.05 \sin.(1.54n + 46^\circ.8) - 0.90 \sin.(4^\circ.1\, n - 13^\circ)$ from which $n = -33.7$ years. Hence the minimum occured in 1796.3.

The effect of the last term is to place the minimum 3.3 years earlier. The former discussion (in 1855) placed the minimum at 1806.1 ± 19.3 years and the mean for all stations then discussed gave 1797.6 + 1.8 years.

By a first and second differentiation of the above formula $v = +45.2$ or *the maximum annual change will occur in* 1875.2.

From the observations since 1750, separately discussed in 1855 T = 1799.5.

From the next following discussion of the magnetic declination at Washington, it is concluded that the maximum declination at the close of the last century was $+0^\circ.42'$ or *the line of no variation* at its highest

ascent at that period *passed below Washington. It certainly passed above Norfolk.* *

The maximum declination will probably be = 4°.42.

In Mr. Schott's discussion of the secular change in C. S. Report for 1859 he mentions that no entire cycle has yet been completed on either the East or West coast. The linear form of the formula first applied to all observations in 1855 (which does not involve any great length of period) is retained for the observations on the Western coast while a circular function is chosen for the others, of which the length of period and other numerical co-efficients have been obtained by the method of least squares. But he adds, "*as long as the cause producing the secular change remains altogether unknown* it is not safe to trust too far to the continuation of the law thus empirically derived."

He finds that "if the stations be arranged geographically, the minimun (West) declination occurred earlier at the Eastern than at the Western and Southern stations." * * * "*and if we proceed to the Western coast we find that the Eastern declination has not yet reached its maximum (equivalent to a Western minimum.)*"

This Report concludes with a record of all declination observations employed in the forgoing papers.

From the preceding imperfect memorandum of the analytical methods of some of the ablest mathematicians and magneticians, who have taken this subject in hand, and especially of those of Mr. Schott, it will be seen :

1st That to the best informed the cause of variation in declination remains still unknown.

2d The mathematical analysis proves the existence of a period including secondary periods, the latter resulting from perturbations due to some cause not identical with the main cause.

3d Over small areas and during short intervals of time the magnetic variation can be predicted and a formula established which shall express it.

4th The linear formula having shown the change of the *kind* of variation in abscissa after a certain epoch and in the *kind* of variation in the ordinate after another epoch establishes the cyclic curve as one of unequal axes.

5th. The easternmost North and South line which is tangent to this curve passes nearly through Washington and some distance west of Philadelphia. The westernmost North and South tangent is not yet determinable with exactness.

* By reference to the Isogonic chart previously mentioned, kindly corrected and sent me by Mr. Schott, March 17, 1876, the highest position attained by the Zero curve is marked in red ink as above Annapolis and Baltimore in 1795, while by computing the mean annual declination from the tables from Report of 1874 (Philadelphia) it will be found that the maximum was from 1740 to 1760 when it amounted to 10′.8, and the minimum from 1800 to 1810 when it amounted to 0′.0

The column for Washington only goes back to 1800 but its minimum seems to have been between 1790 and 1800. From this to the present time this annual mean for Washington presents several irregularities.

6th. The situation of this curve cannot be very near the Terrestrial Pole, since on the same parallel of latitude and with a distance apart of about 2,685 miles, Passamaquoddy Bay shows a (West) declination of + 18° and Salem, Oregon, an Easterly declination of — 20° for the same year. These curves unless forming abnormally acute cusps must meet if produced below lat. 70° as drawn in Col. Sabine's chart.

7th. It is probable that the location of the area of magnetic attraction is nearer to the Atlantic than to the Pacific, because the Isogonic curves of even degrees are nearer together in the former region than in the latter.

8th. Any theory which may be established to account for secular variation must accept the end of the last century or the beginning of this as one of the extremes.

9th. The total period of revolution according to the best data is about 237* years with a margin of a few years error more or less.

10th. The limits within which the declination for a particular date may be calculated for a station, where reliable observations are at hand, is about 8′ to 11′.

The following table was calculated to represent the magnetic variation at Mount Holly, Cumberland Co., Penna., for every five years since 1790, and may serve as an example of how such approximately accurate tables may be obtained for points where the records are very meagre.

In the first place the Isogonic chart of the Coast Survey for1870 (as corrected by the pen of Mr. Chas. A. Schott) was referred to for the positions of various isogonic curves which passed at different dates in the vicinity of Mount Holly. The exceedingly small scale of this chart and the uncertainty of the data from which many of the curves were traced, renders the attainment of the required declination only possible within rather wide limits, amounting perhaps to 20′ if all errors be taken into account; or a little more than the minimum (quarter of a degree) noticed by an ordinary surveyor.

Of course, if the chart be assumed as correct, the error is reduced to less than half this. The method employed for determining these declinations is as follows: After locating the position of the place whose declination is sought on the chart by latitude and longitude, a normal to the isogonic curves of the date required is drawn through this place. The distance apart on this line of the nearest curves of whole degrees between which the place lies, is accurately measured, and afterwards the distance from the point to that one of these curves which is represented by the smallest number of degrees. This distance in the same units multiplied by sixty and divided by the former number will give the number of minutes, which being added to the smallest number of degrees represented by the two curves, furnishes the correct declination of the place at the date for which the curves are drawn. If any actual observations of the declination at the desired locality are at hand these may be compared with the nearest place at which observations have been carried on, and the annual rate of change of the

* See Mr. Schott's Report, *ante*.

amount expressing the difference between the two declinations calculated and noted for each term of years between such data. When observations are entirely wanting, an approximation to the true declination may be made in the manner already described; though the accuracy of such a method will be inversely proportional to the distance along the isogonic normals to old stations of record, and directly as the distance apart of adjacent curves.

Date.	Declination at Philadelphia.	Declination at Mount Holly.	Difference.	Remarks.
1790	West + 2° 24′	West + 0° 14′.54	2° 09′.416	
1795	" 2° 15′	" 0° 5′.17	2° 09′.832	
1800	" 2° 06′	East — 0° 04′.24	2° 10′.248	
1805	" 2° 06′	0° 04′.6	2° 10′.664	
1810	" 2° 06′	0° 05′	2° 11′.08	
1815	" 2° 11′.5[a]	0° 0′ [b]	2° 11′.5	* Subtract 0′.416
1820	" 2° 17′	West + 0° 05′.92	2° 11′.08*	from each difference to obtain the
1825	" 2° 29′.5	" 0° 18′.84	2° 10′.66	next following
1830	" 2° 42′	" 0° 31′.75	2° 10′.248	down to 1845.
1835	" 3° 0′	" 0° 51′.17	2° 09′.832	
1840	" 3° 19′	" 1° 09′.5	2° 09′.416	
1845	" 3° 46′ [a]	" 1° 37′ [b]	2° 09′ †	
1850	" 4° 07′	" 1° 49′.88	2° 17′.12	† Add 1′.625 to
1855	" 4° 33′	" 2° 07′.76	2° 25′.24	each difference to
1860	" 4° 59′	" 2° 26′.62	2° 33′.37	get the difference
1865	" 5° 26′.5	" 2° 45′	2° 41′.5	for the succeeding
1870	" 5° 54′	" 3° 04′.38	2° 49′.62	year.
1875	" 6° 20′	" 3° 22′.25	2° 57′.75	
1877	" 6° 30′ [c]	" 3° 29′ [c]	3° 01′	
1880	" 6° 46′	" 3° 40′.12	3° 05′.875	

a. Interpolation from Assistant Schott's tables of decennial values of magnetic variation, U. S. Coast Survey Report for 1874.

b. From chart of Isogonic lines 1870. The positions of the curves with respect to Mount Holly were measured from additions in pen by Mr. Schott.

c. Observation by Beaton Smith.

Regarding some Mesozoic Ores.

By Persifor Frazer, Jr.

(*Read before the American Philosophical Society, April* 20, 1877.)

There are several places in the New Red Sandstone where, although the presence of no other formation within several miles is intimated on the old map, nor has any sudden change of character in the rock been suspected, there nevertheless appear to be good reasons for supposing that the outer shell of the Mesozoic strata has been worn through and the underlying and older formation has been exposed. One instance (of not much weight, owing to its very local character and its proximity to the actual boundary between the two formations) occurs near Franklintown, York County, near Lerew's tavern, where an oval piece of ground seems to be composed entirely of the older schists, while the contiguous country is made up of the newer shales and sandstones.

The same thing may be noticed near Bendersville and near Arendtsville, where small islands of Mesozoic seem to stand out in a sea of Huronian schists and débris. Many such instances taken from other formations will occur to every geologist, and a glance at the State geological map of the last survey will convey the same fact forcibly through the eye to the mind; for there it will be seen that not only are the bounding edges of the formations ragged, and the shreds of one left within the domains of tl e other, but (sometimes on account of the geographical and orographical conditions under which the original deposition of beds took place; and sometimes owing to the peculiar action of erosion) great peninsulas, islands and archipelagos, are to be seen distinguishing themselves from the formation in which they lie by the colors chosen by Prof. Rogers to represent them.

Such, for instance, are the strips of what Prof. Rogers called Primal and altered Primal which stretch out like an Aleutian chain in the limestone sea of Lancaster and York Counties.

So far as this occurrence of the Huronian rocks within the limits of the New Red Sandstone is concerned, it is important in more ways than one.

1st. As accounting for the presence in the newer of many constituents characteristic of the older rocks in other parts of the country (magnetite, copper ore, etc.); and 2d, in resolving the doubt as to the comparative thickness of the New Red Sandstones at adjacent points.

It has long ago been suggested that the presence of the iron "Glances" in the red shales and sandstones, and the presence in the latter of more or less well defined belts of copper ore, might be accounted for on the supposition that in the making of the newer beds the older were ground up and redistributed (*re-sedimented* would better express the idea).

We know as a fact, adverted to elsewhere, that the only horizons in which copper ores have been found in this State are the South Mountain series of crystalline schists, etc., and these very rocks in question. And even if we seek elsewhere in this country, except a very limited deposit in the Medina

group, and the lean copper shales of the Catskill, none but still more insignificant exhibitions have been noted in other formations.

It might be easier to account for cupriferous shales and sandrocks in the Triassic beds were we sure that ferriferous and cupriferous Huronian rocks were actually in contact with their lower surface, and provided also we could find evidences of such cupriferous and ferriferous horizons among the rocks of the South Mountain system, which are evident lateral continuations of the bed of the Mesozoic sea.

It is true that a copper horizon has been noted in the Orthofelsite of the South Mountain, as at Watson's, Snyder's, etc. in Adams County near Monterey ; and deposits of Micaceous and Specular Iron Ore of very great beauty at G. Coles' near the summit of the Gettysburg-Chambersburg turnpike (both of these in the Huronian series) : and also that many minor occurrences of specular and magnetic iron ore disseminated through the rock in minute crystals (as in specimens found on Green Ridge near Caledonia Springs, etc.) ; but all the deposits thus far discovered will not account for the exceptionally rich character of that portion of the Mesozoic beds which abuts upon the eastern flank of the South Mountain.*

In my report of progress for 1875 (Second Geol. Survey of Penn. CC, p. 328), I have given reasons for the rejection of any theory which implies a local deposit of these ores (*i. e.* only along the borders of the formation), and I have cited eleven localities scattered over the length and breadth of the Mesozoic belt in York and Adams Counties where micaceous ore appears—more or less mixed with magnetite. The copper horizon of Phœnixville seems at first sight to agree well with the views advanced by Dr. Hunt and others concerning the restriction of the metalliferous strata to the two edges of the New Red, for Phœnixville lies very near the southern edge of this formation on the Schuylkill, where it has dwindled down

* Dr. T. Sterry Hunt, in a recently published paper on the "Cornwall Iron Mine and some related deposits in Pennsylvania," states as follows:

"But I have now to bring to your notice" * * * "those ores which are found "over Pennsylvania along both borders of the Mesozoic red sandstone forma- "tion which stretches through the State; including on the south side the ores "of Warwick and the Jones Mine, and on the north side a line of deposits from "Boyertown and the vicinity of Reading to beyond the Susquehanna, includ- "ing the great Cornwall Mine near Lebanon."

"These ores were by Prof. Rogers referred to what he designates the Primal "slates, which he regarded as the lowest member of the Palæozoic series, though "by some later observers the Cornwall Mine and certain related deposits west "of the Susquehanna have been referred to the Mesozoic sandstone. It would "be foreign to my present purpose to set forth the reasons which lead me to "conclude that these are, all of them, really contemporaneous deposits included "in the Primal slates, which corresponds to a portion of the lower Taconic se- "ries of Emmons, and belong, in my opinion, to a lower horizon than the "Potsdam sandstone of the New York system. *That they are met with only along "the borders of the Mesozoic sandstone formation is due to the fact that those ancient "ore-bearing rocks, from their decayed condition and their inferior hardness, have "been removed by denudation, except when protected by the proximity of the newer "sandstones or of eruptive rocks, as is the case at the Cornwall Mine.*"

(Transactions American Institute of Mining Engineers, Vol. IV, p. 320.)

to about half the breadth which it exhibits on the Delaware. It is worthy of note that this contraction of the area of the New Red has been brought about by a sloping inwards towards the median line of both its north and south boundaries, so that if the breadth of the Mesozoic rocks on the Delaware were continued to the Maryland line, this ore region would fall but little below the axis of the belt. Furthermore, this position would accord well with that of the copper ore deposit in Bonnaughtown, about eight kilometers (or five miles) east of Gettysburg.

The same argument may be applied to the iron ores of the Altland mines, which are cut in specular, somewhat magnetic and very cupriferous ore, for this locality lies 11 kilometers (or 6⅘ miles) S. E. of the N. W. limit of the New Red.

If the same view be held to explain the Cornwall deposit and the Altland deposit the latter must be of ante-Potsdam age. This, however, is not at all yet sustained by observation.

Again, if the source of all this magnetic-micaceous ore be assumed to be the older slates, then it seems to indicate that the greater part of the sand obtained by wearing the shores of the Mesozoic sea was obtained from the Huronian rocks, for over every kilometer (⅗ mile) of the breadth of the deposit in York and Adams will be found *some* flaky "iron-glimmer," besides many belts of shale and sandstone, colored green with the débris of the Huronian chlorites and sparkling with the hydro-micas of the same age.

Now supposing that this were true, *i. e.* that either the greater part of the Mesozoic sandstone rocks, or at least a large proportion of them, taken in any part of the belt, consisted of the débris of the Huronian schists worked over, it might prove a connection between these ore deposits, but a few miles from the South Mountain, and those of the latter: independently of whether the shallow but monoclinal structure of these beds (as explained by the wave strewing hypothesis of H. D. Rogers; or the deepening trough-bottom hypothesis of J. D. Dana),* or the normal deposition, folding and subsequent erosion shall be assumed, for even in this latter case a margin of a certain width along the coast line, where the water was shallow, would show in the deposits the characters of the original rock forming its shelving bottom.

So that in any case we should look for the Huronian source under the present position of the ore, because the waves which broke up the shallow bottom would strew the débris in the immediate vicinity of the parent rock.

[In Rogers' hypothesis the direction of the apparent motion of the wave is the really important factor, and it is difficult to understand why we should not have S. E. dips on the S. E. margin of the Mesozoic estuary, since the waves are supposed to produce layers dipping in shore. (See diagram, Vol. II, Part II, p. 812, Final Report on the Geology of Pennsylvania.)† Or vice versa if the *suspension* hypothesis (ibid. diagram p. 813) be preferred.]

But, abandoning this wave-strewing hypothesis as altogether inadequate

* Manual of Geology, 1875, p. 421. † 1858.

to account for beds of such depth as those we find in the New Red, we may nevertheless consider the effect of the waves in forming strata of sediment in the shallow portions adjacent to the coast (which here seems to have been the South Mountain).

The direction of the line of Section 7, Report for 1875 C C (which corresponds with the South Mountain portion of the Section of the same number in Roger's final Report) was chosen, after an examination of the plotted work in that region permitted a mean of all the mountain dips to be taken. The direction of this mean dip was chosen as the direction of the section line because it was the line most nearly corresponding with all the observed dips. A direction perpendicular to this will therefore represent with the nearest approach to exactness the strike of the old Huronian rock.

These mean dip and strike lines are constant for the entire portion of the South Mountain here under consideration.

This strike is E. 27°N.

The strike of the New Red Sandstone rocks contiguous to the above Huronian rocks was calculated in the same way, for Section 6a (the nearest Section) and is E. 40°N.

These lines thus intersect each other at an angle of 13°.

If we assume that all the New Red Sandstone rocks which cover a strip of country from 10 to 12 kilometers (6¼ to 7½ miles) from the base of the South Mountain were parts of the shallow or littoral Mesozoic sea, and therefore especially subjected to the wasting action of the waves; it is natural that the ore belt of the new forming rocks must follow approximately the ore line below, and since only in a limited margin beyond the actual breadth of the parent bed is it likely that the ore would show in the new formation, it might appear as if deposited in a vein more or less clearly defined, and following a course of about E. 27° N. It should be here emphasized that this might be so independently of the accuracy or error of the wave-strewing hypothesis, and independently of whether their present dips were acquired then or subsequently; provided only that the new rocks were forming on, and from the old. But whether or not this be the case, the following phenomena are interesting.

The mines known as the Dillsburg Group lie too close together to enable one to predicate anything with confidence from them alone as to the direction of the one or more belts of ore in which they are sunk, but if we connect together the three northeasternmost ore properties mentioned in General Map C C 1875. (Meyer's, Ellicker's and Kimmel's) with the group around Franklintown, the line is very nearly E. 25° N. *i. e.* that of the above mentioned strike of the Huronian measures. Moreover there does seem to be a certain conformability of the Dillsburg and other groups to this line. [N. B.—The strike of sandstone 60 ft. down in the Altland bank group is about E. 30° N.—nearly the same.]

It chances that the average dip of the South Mountain rocks remains pretty uniform from N. E. to S. W., so that if there were any foundation

for the supposition, we ought to be able to follow one or more belts of ore in a tolerably straight course from one formation into the other.

On the general map to illustrate the report of 1875, lines were drawn from the Franklintown ore diggings, E. 27° N. and W. 27° S. The first of these passes through the locality where ore has been prospected at Meyers', Ellicker's, and Kimmel's. The W. 27° S. line passes through the town of Whitestown (or Idaville), where was a once famous iron mine. All these three occurrences are clear of the mountain range. The first two are in the New Red, the last in the older (Huronian) crystalline schists or in the mixed marginal formation. Continuing this line still further W. 27° S. it cuts the very singular ore mine of G. Coles in the Catholic Valley (a small valley among the South Mountain ridges). This same line emerges in the Cumberland Valley where several new ore pits sunk by Col. Wiestling have proved the existence of ore.*

Drawing a parallel line of W. 27° S. from the Dillsburg group, we cross the Bender, McCormick and Williams limonite mines in the first high land of the mountains about 6.5 kilometers (or a little more than four miles) S. W. of Dillsburg. Near the Chambersburg turnpike this line crosses the "Furnace bank" opening, which can be seen from the turnpike on the brow of a steep hill just across (W. of) the Connococheaque.

If we move the parallel ruler from this line till it pass through Pine Grove, and draw another line, this latter will very nearly pass through Medler and Sayler's and the Thomas Iron Co.'s banks S. E. of Papertown, in one direction, and through the Hoosac Run Mine of the old Caledonia Furnace property in the other, emerging from the mountains near the mouth of Cold Spring Ravine at the ore opening of Mr. Good.

Thus it will be remarked that not only does the characteristic strike line of the old Huronian rocks enable us to pass from known ore localities in the older, to known localities in the newer formation; but all the important mines of this particular region yet known in both formations can be connected together by two or three such lines.

* It is doubtful if the latter is more than a coincidence, as the portion of this line between Coles' ore mine and the Cumberland Valley probably crosses the line of a great fault and thrust: the most important dynamic element in the formation of these mountains.

American Condensed Peat: Experimental Tests to Determine its Value for Blast and Puddling Furnace Use, &c.

BY J. BLODGET BRITTON.

(*Read before the American Philosophical Society, April 20, 1877.*)

At the meeting of the fifth of January last I exhibited a small sample of condensed air-dried peat, prepared by the Dodge process, at works in operation near Syracuse, N. Y., under the direction of Jas. M. Hart and others, and stated that my purpose was to ascertain by analysis its general composition in order to find what value it possessed for blast and puddling furnace use and generating steam in boilers, and would communicate to the Society the results obtained. Since then I have received more of the same material charred, and some samples prepared by the Wright process, at works at Rome, N. Y., under the direction of the patentee, W. E. Wright; and also some samples of true brown coal or lignite, apparently a derivative of peat, found in considerable quantity in more or less disconnected deposits of from one to seven feet in thickness, principally in the region of the Ouachita River in Southern Arkansas. In order to embrace in the communication the results of the analyses of these last samples, there has been more delay than was anticipated. Portions of the samples are now presented for inspection and comparison, and also I respectfully submit the results of the analytical examinations so far made.

The lignite has a specific gravity of 1.29. It is lighter in color than the peats, and more uniform in structure, but by exposure to a drying atmosphere, however slowly the drying is effected, becomes quite friable, and at once breaks into pieces when roughly handled. It ignites most readily, and with a draft gives a long, bright flame and very little smoke, but would not answer the purposes of the blacksmith; it does not cake or form a coherent coke.

Results of analysis.

Water	23.62
Crude oleaginous matter	12.49
Other volatile matter more or less combustible	28.44
Ash	4.85
Fixed carbonaceous matter	30.60
Total	100.00

Included in the above:

Sulphur	.551
Sulphuric acid	.322
Phosphoric acid	.007

Composition of the Ash.

Ferric oxide	24.45
Silica	40.14
Alumina	26.61
Lime	6.31
Magnesia	.16
Sulphuric acid	.60
Phosphoric acid	.12
Alkali, undetected matter and loss	1.61
Total	100.00

The sample of peat marked "From Illinois" (about 1 lb.), came with the one from the Syracuse Works, and was prepared, it is supposed, by the Dodge process, specific gravity 1.32.

Results of Analysis.

Water	13.90
Volatile matter more or less combustible	48.70
Ash	15.26
Fixed carbonaceous matter	22.14
Total	100.00

Included in the above:

Sulphuric acid	.30
Phosphoric acid	practically none

Composition of the Ash.

Ferric oxide	9.50
Silica	43.00
Alumina	18.20
Lime	24.41
Magnesia	.18
Manganous oxide	.22
Sulphuric acid	1.90
Phosphoric acid	trace
Alkali, undetected matter and loss	2.59
Total	100.00

The sample of peat from the Syracuse Works (about 40 lbs.) was dug from an extensive bog nine miles north of the city, and prepared by grinding into pulp in a bath of water and then draining and air-drying. The cost of the material in quantity, cut and broken into pieces somewhat larger than a man's fist, and dried in condition like the sample exhibited, is stated to be not exceeding $1.25 per gross ton. It is not at all friable

but, on the contrary, is tough and strong, and will bear rougher handling than many of the bituminous coals. It ignites readily, and, like the lignite, burns with a long, bright flame and little smoke. The specific gravity of the pieces tested varied considerably from below 1 to 1.28; not more than one-half of them sunk in water.

Results of Analysis.

Water	21.68
Crude oleaginous and tarry matter	16.47
Other volatile matter more or less combustible	28.27
Ash	8.12
Fixed carbonaceous matter	25.46
Total	100.00

Included in the above:

Sulphuric acid	2.325
Phosphoric acid	.068

Composition of the Ash.

Ferric oxide	7.55
Silica	13.35
Alumina	6.54
Lime	44.31
Magnesia	1.26
Manganous oxide	trace
Sulphuric acid	21.60
Phosphoric acid	.74
Alkali, undetected matter and loss	4.65
Total	100.00

The sample of charred peat (about 8 lbs.) had an average specific gravity of 1.22. It was friable, and with ordinary handling broke into pieces of the size of a walnut and less. A portion of it was thoroughly dried, but afterward found to reabsorb moisture from the atmosphere readily; exposed to the air in a chamber of the laboratory, it regained 7.20 per cent. in 48 hours.

Results of Analysis.

Water	13.10
Volatile matter more or less combustible	22.69
Ash	15.27
Fixed carbonaceous matter	48.94
Total	100.00

These results show that the material had not been thoroughly coked, but merely charred. Tested in a good 12 inch wind assay furnace it

failed to produce heat sufficient for the reduction of an ore of iron to a button of metal; the quantity, though, was scarcely sufficient for a conclusive test. It burned with a roar, and gave flame enough to heat the pipe red-hot for some distance, which I never found anthracite to do in the same furnace.

The sample of peat from Rome, N. Y. (about 50 lbs.), was dug from a bog in Oneida county, where large bodies of it exist, and prepared by first grinding into pulp, then partially compressing and air-drying, and, lastly, more completely drying in a current of air artificially heated. The cost of preparing in quantity is estimated at under $1.50 per gross ton. The pieces, like those of Syracuse article, are of suitable size, tough and strong. The specific gravity varied mostly between 1 and 1.21; nearly all of the pieces tested sank in water.

Results of Analysis.

Water	14.39
Crude oleaginous and tarry matter	19.77
Other volatile matter more or less combustible	30.59
Ash	12.40
Fixed carbonaceous matter	22.85
Total	100.00

Included in the above:

Sulphuric acid	1.44
Phosphoric acid	.17

Composition of the Ash.

Ferric oxide	7.91
Silica	35.24
Alumina	14.83
Lime	25.21
Magnesia	.36
Manganous oxide	1.05
Sulphuric acid	11.32
Phosphoric acid	1.35
Alkali, undetected matter and loss	2.73
Total	100.00

A portion of this sample was tested in the assay furnace with about the same effect as that produced by the charred peat. Another portion was tested for liability to absorb moisture from the atmosphere, and found to regain 7.70 per cent. at a temperature between 65° and 73° F. in three days. What it would regain out of doors in a covered, latticed bin can be inferred.

From the facts stated it is clear that neither of the samples examined would be equal to wood charcoal for use in blast furnaces as they are now

constructed; if, unmixed with other fuel, they would answer for such use at all with profit. If they were coked and made into a compact coal, tough enough to withstand the pressure and abrasion of the ore and flux without unduly crushing—which, I believe, would be quite impracticable with the lignite—they might answer well; the large quantity of ash they contain would be the only objection. The ash, however, being rich in lime and also containing some potash and soda, would not prove very refractory. The sulphuric acid would not become reduced and give sulphur to the iron, but pass off mostly as sulphate in the slag, and the phosphorus present being small would have little effect. The peat from Illinois would afford 68.92 of ash with 100 parts of fixed carbon, that from Syracuse 31.50, and that from Rome 54.22. Wood charcoal usually affords less than 1 per cent. of ash; coke from bituminous coal, variable, but usually less than 12 per cent., and anthracite, also variable, but usually less than 8 per cent.

As a fuel for use in puddling furnaces these condensed peats would unquestionably answer, and best when well dried. They would burn freely without caking or forming any undue amount of clinker, require no excess of blast or draft, and afford combustible gas free from sulphur in greater volume than the ordinary bituminous coals. By mixing the gas with heated air at or near the bridge walls, an exceedingly high heat could be produced. For use in the Siemens regenerative furnace they would be especially well adapted, their contents of moisture being no disadvantage, but decidedly beneficial. Burning, as they could be made to, with a long, hot and almost smokeless flame, their value for the production of steam in stationary and other boilers would be great, and for the production of an illuminating gas of high candle power they would be no less valuable. I regard them as not at all liable to spontaneous combustion.

Much has been said of the value of peat for fuel purposes. The literature upon the subject is voluminous. My conclusions, however, are not drawn from anything hitherto published, but alone from the facts revealed by the analyses and tests made as stated. Peats differ more or less, and some very widely in the relative proportions of their constituents, and their fitness for use depends materially upon the manner in which they are prepared; hence, to determine the true value of any one, a chemical analysis and other tests should be resorted to.

Stated Meeting, April 6, 1877.

Present 19 members.

Vice-President, Mr. PRICE, in the Chair.

Letters accepting membership were received from E. H. Von Baumhauer, Harlem, March 7, 1877; from C. Wm. Siemens, 12 Queen Ann's Gate, Westminster, S. W., March 14, 1877; and from Mariano Barcena, dated Meteorological Central Observatory, Mexico, March 25, 1877.

Letters of acknowledgment were received from the Academy at St. Petersburg, February 26 (62, 74, 97); Royal Society of Sciences, Göttingen, February, 1877 (97); Royal Library, Leipzig, February 4 (97); S. de Phy. Geneva, December 1, 1876 (94, 95, XV, ii); Royal Danish Academy, Copenhagen, March 13 (97); Chicago Academy of Science, March 6 (Proc. 16, 17, 33, 35 to 39, Vol. III, Vol. V, wanting 44, Vol. VIII to XIV, 78, 94, 95, 96, 98).

Letters of envoy were received from Dr. A. Dreschler, Dresden, February 11; Royal Academy, Vienna, September 29, 1876; Royal Observatory, Greenwich, March 1877; Meteorological Office, London, March 1877; Howard College Observatory, April 3; United States Lighthouse Board, March 22; United States Naval Observatory, January 31; and the Department of the Interior, April 3, 1877.

Donations for the Library were received from the Nic. Observatory, St. Petersburg; Royal Danish Academy; Royal Academy, Vienna; M. Adolph Dreschler; the Society at Ulm; Neu Lausitz. Magazin, Görlitz; N. H. S. Bonn; Royal Society Göttingen; Flora Batava; S. de Phy. and M. H. de Saussure, Geneva; Royal Academy of Lincei, Rome; National Library and Faculty of Medicine, Madrid; Society of the Friends of Peace at Valentia; Central Geographical Commission of Lisbon; Portuguese Commissioners to the Centennial; Royal Astron. Society, Society of Arts, and Nature, London: Lit. and P. Society, Liverpool; Astronomical Observatory, Harvard College: Com.

Corr. Old South Church, Boston: B. N. H. S.; Silliman's Journal; American Chemist: Geological Survey of New Jersey: Academy Natural Science; Franklin Institute: College of Pharmacy, and E. D. Cope; United States Naval Observatory; Signal Service Office; Light House Board: Botanical Gazette, Hanover, Ind.; University of California, Berkeley; and the Brazilian Biographical Annual, Rio de Janeiro.

The death of Prof. J. S. Hart, aged 67, at his residence in Philadelphia, March 26, 1877, was announced by the Secretary.

Prof. Frazer exhibited and described the construction and use of a new compass devised by Major Brooks, for field work, to detect and measure local attraction more accurately than the ordinary dipping needle.

Prof. Frazer communicated a paper on Magnetic Declination.

The Secretary read a paper, entitled "On the relative ages of the Sun and certain of the Fixed Stars, by Prof. Daniel Kirkwood of Indiana University," which was discussed by the members present.

The Secretary presented, for Dr. Brinton, a paper, entitled "The Timucua Language, by Albert S. Gatschet."

The Secretary read a short communication from Mr. C. E. Hall, entitled "Contribution to the Palæontological Museum of the Second Geological Survey of Pennsylvania," describing the late discoveries of Eurypterus (hitherto characteristic of the Silurian Water Lime rocks) in the Subcarboniferous and Carboniferous of Northern and Western Pennsylvania, by Mr. Carll and Mr. Mansfield.

Dr. Le Conte read portions of a private letter and described the activity of the new Society of Sciences at Davenport, Iowa;—on motion the placing of that Society on the list of Correspondents was referred to the Publication Committee.

On motion the Secretaries were authorized to accept Mr. Sinclair's contract to make for $25 a piece, two plates to il-

lustrate Prof. Cope's paper on the brain of Coryphodon Elephantopus.

Mr. E. K. Price offered the following resolution which was seconded and passed:

Resolved, That since by the death of Messrs. Durand, Trego and Guillou, there are three vacancies in the Committee on the Michaux Legacy, that said vacancies be now filled by new appointments.

Mr. Joseph P. Townsend, Mr. Aubrey H. Smith, and Mr. W. M. Tilghman, nominated respectively by Mr. Price, Dr. Cresson and Mr. J. S. Price, were elected to fill the vacancies.

Mr. E. K. Price offered the following resolution, which was seconded and passed:

Resolved, That the Committee on the Michaux Legacy be authorized to consider and report to the Society, from time to time, what appropriations should be made of the residue of the income of that Legacy, so that the purposes of his will may be faithfully executed.

Dr. Barker having explained that Prof. Draper, elected member of this Society in 1844, had never received copies of the Proceedings, and there being no likelihood that the Society would incur at present the expense of reprinting the exhausted numbers of the series, it was moved and adopted that the Secretaries be authorized to make an exception specially in his case, and take one of the twenty reserved sets, from the beginning, and present it to Prof. Draper.

Pending nominations number 830 to 834, 835, and new nomination 836 were read.

And the meeting was adjourned.

Stated Meeting, April 20th, 1877.

Present, 15 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of envoy were received from the Austrian Academy, Vienna, November 1, 1876.

Letters of acknowledgment were received from the Royal Society, Edinburgh, Dec. 1876 (XV, ii, 94. 95); and the McGill University, Montreal, April 5, 1876.

Donations for the Library were received from the Austrian Academy, many volumes of the Novara Expedition; the Royal Society, Melbourne; the Geographical Society and Revue Politique, Paris; Lord Lindsay (Editor of the Dunn Observatory Observations), and London Nature; the Royal Edinburgh Society; Essex Institute; White Mountain Alpine Club (Appalachia), Boston; Antiquarian Society, Worcester; American Chemist; A. N. Williamson, M. D., New York; Buffalo Society of Natural Sciences; A. Journal Medical Sciences; Medical News; Penn Monthly; Committee of National Centennial Celebration, Philadelphia; U. S. Department of the Interior; and the Botannical Gazette, Hanover, Indiana.

The death of a member, Dr. Alexander Braun, at Berlin, March 29, 1877, aged 71, was announced by a circular family letter.

Mr. Britton exhibited specimens of lignite and peat, and pressed fuel from peat manufactured in the State of New York, and read a paper explanatory of the process and value of the fuel, with analyses made in his own laboratory.

Several written communications handed to the Secretary for presentation to the American Philosophical Society, by the Rev. J. L. Gross, were read by title by the Secretary.

Professor Frazer read a communication of facts which he had observed in his survey of York and Adams Counties, Pennsylvania, and discussed the views of Prof. H. D. Rogers and others respecting the cause of the general north-west dip of the New Red and of the origin of the magnetic and specular iron ore beds of the New Red and of the Azoic rocks of the South Mountains, insisting specially upon one point, viz.: that parallel straight lines about N. 20 E. may be drawn through all the ore banks of any consequence, irrespective of their habitat in the two formations; a fact which seems to make the ores common to both by some law not yet

discovered. He presented for the examination of the members in support of this fact, one of the recently published maps of his district.

Pending nominations, Nos. 830 to 836 and new nominations Nos. 837 and 838 were read.

Pending nominations, Nos. 830 to 835 were spoken to and balloted for.

The Resolutions of Prof. Frazer to recommend the addition of metric units to English units in papers prepared by members for publication; and Dr. Roger's amendment to order the conversion of metric units when used into English units, postponed from March 16, 1876, were called up, debated at much length, and not agreed to.

The ballot boxes being scrutinized by the presiding officer, the following persons were declared duly elected members of this Society.

830. Prof. Henry Draper, M. D., of New York City.

831. Dr. J. T. Rothrock, Prof. Botany, University, Pa.

832. Mr. James Douglass of Phœnixville, Pa.

833. Prof. J. J. Stevenson, University of New York, and Assistant Geologist Second Geological Survey of Pennsylvania.

834. Dr. George R. Moorhouse, of Philadelphia.

835. Dr. T. B. Reed, of Philadelphia.

And the Society was adjourned.

Stated Meeting, May 4th, 1877.

Present 16 members.

Vice-President, Mr. Price, in the Chair.

Mr. H. Armitt Brown, a newly elected member was introduced to the presiding officer and took his seat.

Letters accepting membership were received from Prof. J. J. Stevenson, 314 West Thirtieth Street, New York, April

24, 1877; Dr. Thos. B. Reed, dated Philadelphia, April 24, 1877: Prof. Henry Draper, 271 Madison Avenue, New York, April 24; Dr. Geo. R. Moorhouse, 227 South Ninth Street, Philadelphia, April 25, 1877.

Letters of acknowledgment were received from the Imperial Russian Society (95,97); Imperial Central Meteorological Establishment (97); and the Astronomical Society at Leipzig (97).

A letter of envoy was received from the Meteorological Office in London.

Donations for the Library were received from the Berlin Horticultural Union and African Exploration Society; the Vienna Anthropological Society and Geological Establishment: the Brussels Academy, and Netherland Botanical Society; Annales des Mines; London Astronomical, Asiatic, Antiquarian and Zöological Societies; Meteorological Office, and Editors of Nature: Greenwich and Radcliff Observatories; and the Observatory at the Cape of Good Hope: Mr. James Young and Mr. R. Angus Smith of Edinburgh; the Essex Institute; Silliman's Journal; Franklin Institute: College of Pharmacy: Prof. Cope and Mr. J. Meehan; the University of Virginia; Wisconsin Academy of Sciences: and M. Barcena of Mexico.

The death of General Wm. A. Stokes, at Philadelphia, May 3, in the 63d year of his age, was announced by Mr. Price.

Prof. Cope exhibited and described a plaster cast of the Cranial Cavity of a fossil *Procamelus Occidentalis*, from near Sante Fé, New Mexico, comparing it with the brain of the llama.*

Prof. Cope communicated a catalogue of 43 species, (about 20 of them new) of living batrachia; entitled "Synopsis of the cold-blooded vertebrata procured by Prof. James Orton during his explorations of Peru in 1876-77." Prof. Orton has added greatly to the value of his catalogue by

*This and following communications will be published in the next volume (XVII) and No. (100) of the Proceedings.

giving the elevation above tide at which each species was noticed. Thus, a *Bufo* was seen ranging from the seaboard to a height of 14,500′, without material noticeable change of aspect.

Prof. Sadtler communicated a paper "On some new chlorine derivations from Toluole, by Dr. E. F. Smith of the University of Pennsylvania.

Mr. Lesley communicated and read a part of a Report by Mr. J. F. Carll, Assistant Geologist on the Second Survey of Pennsylvania in charge of the Oil District; describing the success and method of his efforts to regulate and harmonize the Railroad and Oil Well Levels above tide in North-western Pennsylvania.

Pending nominations 836, 837, 838, were read.

Dr. Rogers announced that the Committee on the Wooten Slack-Burner would be ready to report at the next meeting of the Society.

Mr. Fraley reported that he had paid into the Treasury $143.07, being interest due on the Michaux Legacy, April 1, 1877.

Mr. Price, Chairman of the Committee on the Michaux Legacy reported the action of the Committee at its meeting April, 25, 1877, as follows:

Report.

"At a meeting of the Committee on the Michaux Legacy, held April 25, 1877, present, F. Fraley, Aubrey H. Smith, Wm. M. Tilghman, Jos. B. Townsend, and Eli K. Price.

"On motion it was resolved to recommend an appropriation of two hundred dollars for the expenses of a course of Lectures contributing to the extension and progress of Silvyculture, to be delivered by Dr. T. F. Rothrock, of the University of Pennsylvania.

"*Resolved*, That the Chairman of this Committee be requested to confer with Dr. Rothrock, with the view to the preparation of a syllabus of such a course, and the time and plan for the delivery thereof, in case the above resolutions should meet the approbation of the Society.

"Dr. Rothrock afterwards met the Chairman and Mr. Fraley, and consents to lecture once a week in the Park, and to fill out the syllabus herewith reported."

[Signed.] ELI K. PRICE, CHAIRMAN.

The following resolution offered by Mr. Price with a blank for the sum to be appropriated, was debated at length, the blank filled, and passed unanimously:

Resolved, That an appropriation of four hundred and fifty dollars ($450) be made out of the income of the Michaux Legacy, to defray the expenses of a course of lectures in Horticultural Hall, Fairmount Park, on Silvyculture, to be delivered by Dr. Rothrock.

And the meeting was then adjourned.

Syllabus of Lectures on Silvyculture.

To Mr. Eli K. Price,

Chairman of the Committee on the Michaux Fund of the American Philosophical Society, and of the Committee on Trees and Nurseries of the Fairmount Park Commissioners.

Dear Sir:—I have the honor to submit the following as an outline of the proposed Lectures in the Park:

1. Sketch of André Francois Michaux. Outline of the journeys made by him and by his father in North America. The primary object being the introduction into France of American plants and especially American trees. This was an early recognition there of the actual necessity of Arboriculture in its relation to the future. Provision made by William Penn, July 11, 1681, that "in clearing the ground care be taken to leave one acre of trees for every five acres cleared, especially to preserve Oak and Mulberry Trees for silk and shipping." Tree destroying tendency of the American people has been matured into an instinct.

2. Recognized need in Europe of replacing forests destroyed and of protecting those that remain has developed a matured system of Forestry. Give an outline of this system.

3. Immediate necessity for some such system in the United States, growing out of ruthless destruction of our extreme forests. Immediate action required to prevent serious injury to the future interests of commerce and of the arts in our country by a continuance of this unrestrained destruction, without any corresponding measures being taken to replace the first growth.

4. Influence of extensive forests (and vegetation generally) on face of country: 1st, from an æsthetic point as illustrated by Humboldt's Views of Nature; 2d, by either increasing or conserving rain fall; 3d, by preventing rapid evaporation on one hand and destructive freshets on the other; 4th, by moderating climate, *i. e.*, warding off destructive winds.

and by supplying aqueous vapor to prevent a too free radiation of the earth's heat back into space at night.

5 and 6. Distribution of Forests in North America ; their present and prospective relation to the wants of man.

7 and 8. Treeless regions of North America. How they limit areas of cultivation by increasing areas of evaporation. How can the area of these treeless regions be decreased, and at the same time made routes for conducting water to areas of cultivation?

9. Necessity for such measures : Result—a true and legitimate economy in government to aid in them.

10 and 11. Economic Arboriculture, as related to homes, home health and the useful arts.

12. Exotic trees to be introduced, and the propriety of government supporting extensive experimental and propagating arboretums.

13 and 14. Plants of cultivation and the changes produced by cultivation in them.

15. How plants are constructed, *i. e.*, popular sketch of their anatomy.

16. How plants are perpetuated and how they "behave."

17. Means taken to distribute them over the globe, and some striking examples furnished.

18. Succession of vegetable life on the globe.

19. Chemistry of vegetation.

20. Evidences of design in the vegetable kingdom.

In the above I have endeavored to keep within the limitation implied in the will of André Francois Michaux, *i. e.*, that his legacy was intended to contribute to the extension and progress of Agriculture and more especially in Silvyculture in the United States.

Very respectfully, J. T. ROTHROCK.

May 2, 1877.

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